ecology and environment, inc.
Global Environmental Specialists
720 Third Avenue, Suite 1700
Seattle, Washington 98104
Tel: (206) 624-9537, Fax: (206) 621-9832

April 4, 2017

Mike Boykin, On-Scene Coordinator
United States Environmental Protection Agency, Region 10
1200 Sixth Avenue, ECL-133
Seattle, WA 98101

RE: Trip Report, Opalite Mine Removal Assessment, Malheur County, Oregon
Contract Number EP-S7-13-07, Technical Direction Document Number 17-03-0004

Dear Mr. Boykin:

Enclosed please find the final Trip Report for the Opalite Mine Removal Assessment. If you have any questions regarding this document, please call me at (206) 624-9537.

Sincerely,

Steven G. Hall
START-IV Removal Team Leader

Enclosure

This page intentionally left blank.

TRIP REPORT

Opalite Mine
2016 Removal Assessment
Malheur County, Oregon
TDDs: 16-03-0008 and 17-03-0004

Prepared for

U.S. Environmental Protection Agency, Region 10
1200 Sixth Avenue
Seattle, Washington 98101

Prepared by

Ecology and Environment, Inc.
720 Third Avenue, Suite 1700
Seattle, Washington 98104

April 2017

This page intentionally left blank.

1. PLACE VISITED

Site Name:	Opalite Mine
Owner Name:	Bradley Mining Company
Location:	Section 33, Township 40 South, Range 40 East, W.M., Tax Lot #700, Malheur County, Oregon (Figure 1)
Date of Trip:	August 9, 2016
SSID:	10PY
CERCLIS ID:	ORN001002255
Latitude:	42.050945
Longitude:	-118.035992

2. PURPOSE

The United States Environmental Protection Agency (EPA) tasked Ecology and Environment, Inc. (E & E), under Superfund Technical Assessment and Response Team (START) contract number EP-S7-13-07, Technical Direction Document (TDD) numbers 16-03-0008 and 17-03-0004[*], to support an EPA-led removal assessment at the Opalite Mine Site, an inactive mercury mine located on patented mining claims in the extreme southern end of Malheur County, Oregon, approximately 16 miles northwest of McDermitt, Nevada (Figure 1). The mine is surrounded by public land administered by the Vale District of the Bureau of Land Management. The site is approximately 342 acres in size. The elevation of the site is between approximately 5,200 and 5,400 feet above sea level. The climate of the area is arid, and the sparse vegetation consists of grasses, sagebrush, and other shrubs. Mine Creek flows towards the south along the west side of the site. An unnamed tributary of Cowboy Creek flows toward the southeast along the east side of the site (ODEQ 2001, E & E 2005).

Removal assessment activities were performed on August 9, 2016. Test pit excavation was performed by Environmental Quality Management, Inc. (EQM) as the EPA Region 10 Emergency and Rapid Response Services (ERRS) contractor. A representative from the Oregon Department of Environmental Quality (ODEQ) was also present on site and assisted with the removal assessment. As part of the removal assessment activities, START was tasked to monitor site conditions through logbook entries and photographic documentation. Attachment 1 contains photographs taken at the site during the removal action.

[*] Field work and the draft trip report were completed under TDD number 16-03-0008. This trip report was finalized under TDD number 17-03-0004.

3. BACKGROUND

3.1 Site Description and Operational History

The Opalite Mine is an abandoned mercury mine and ore processing facility. The Opalite mercury deposit was discovered by William Bretz in 1924. In April 1925, F.W. Bradley formed the Mercury Mining Syndicate and began development of the Opalite Mine. The mine was developed using the glory hole method, in which adits or tunnels were driven horizontally beneath the ore body, and raises and inclines were driven upward to the surface to remove the near-surface ore deposit from the glory hole. The Opalite Mine workings include a Glory Hole (also referred to as the open pit), #1 Adit (also previously referred to as Tunnel No. 1), #2 Adit (also previously referred to as Tunnel No. 2), two large trenches located northeast of the Glory Hole (referred to as the Northeast Trench and Southwest Trench), numerous shafts, raises, winzes, and inclines/declines, and numerous smaller exploratory prospects and excavations. Other mine features include overburden and waste rock piles, remains of ore processing facilities, and two large piles of thermally processed ore (referred to as the Northern and Southern Burned Ore Piles. Key features are illustrated in Figure 2.

A furnace was constructed in the Ore Processing Area in 1926 to process the ore recovered from the Opalite Mine as well as ore concentrates transported by truck from the nearby Bretz Mine. Ore processing at the Opalite Mine is discussed further below.

3.2 Geology and Mineralogy of the Opalite Mine

Geology of the Opalite Mine is discussed in detail by Schuette (1938), Yates (1942), Brooks (1963), and Brooks (1971) and briefly summarized based on these sources below. The rocks of the Opalite Mine area consist of more than 3,000 feet of nearly flat-lying Miocene lavas overlain by upper Miocene tuffaceous lake beds. The lake beds, which are locally more than 200 feet thick, contain the ore bodies of the Opalite Mine as well as the nearby Bretz Mine. The Miocene rocks are locally cut by steep normal faults, some of which served as conduits for rising hydrothermal fluids. Locally, these fluids silicified the adjacent tuffs and lake beds into bodies of opalite. The silicification was accompanied by local kaolinitization of the lake beds. The Opalite Mine ore bodies are in contact with the silicified rocks. The Opalite Mine ore body occurred as a mass of chalcedony approximately 1,200 feet long, 800 feet wide, and up to more than 100 feet thick. Mercury mineralization occurred during a late stage of hydrothermal activity.

In general, one of the most common types of mercury deposits in Nevada, including the Opalite District that encompasses the Opalite Mine, is "opalite," which is composed of amorphous and cryptocrystalline quartz including opal. The ore mineralogy of these mercury deposits is predominantly cinnabar (mercuric sulfide, HgS), with subordinate amounts of metacinnabar (mercuric sulfide, m-HgS), native elemental mercury (Hg^0), calomel (mercurous chloride, Hg_2Cl_2), and mercury oxychlorides found in some deposits. Minor amounts of pyrite, marcasite, sphalerite, and stibnite are found with cinnabar ore in a few localities. (Gray et al. 1999)

At the Opalite Mine, the principal ore mineral is cinnabar, which is mixed with the silica in the chalcedonic ore bodies and forms disseminated crystals in the unsilicified rocks. Although the principal ore mineral at the Opalite Mine and elsewhere in the Opalite District is cinnabar, elemental mercury and the relatively rare oxychlorides of mercury also have been documented. The gangue minerals in the siliceous ores are chalcedony, quartz, and opal. The chalcedony, which is the most abundant gangue mineral, is hard and dense and ranges from white to dark gray. (Yates 1942)

The cinnabar of the Opalite District occurs in three forms: disseminated as small crystals in the lake sediments (at the Bretz Mine); intimately mixed with silica in chalcedony; and coating slip and joint faces as a pulverulent "paint" which may be of supergene origin. Because the cinnabar in the chalcedony blackens rapidly when exposed to sunlight, it is not easily recognized except in freshly broken rock. Elemental mercury was observed in the open pit at the Opalite Mine, where it is associated with terlinguaite (Hg_2ClO) and cinnabar. It was reported to be common in some of the Opalite Mine ore as globules that fill cracks and small vugs in the chalcedony. The richness of some of the Opalite Mine ore was due to appreciable amounts of elemental mercury and accompanying terlinguaite. Terlinguaite is a canary-yellow powder that rapidly turns green and then black when exposed to air and sunlight. It was formed later than the cinnabar and is found in vugs and along open cracks. (Yates 1942)

Information on other minerals, including arsenic and antimony species, for the Opalite Mine is not available. However, realgar (arsenic sulfide, AsS) was observed in a cut just east of the Bretz Mine (Yates 1942).

3.3 Ore Processing

In general, processing of mercury ore is a relatively straightforward process, usually involving roasting of the ore to thermally decompose the mercury compounds present in the ore and collecting the resulting elemental mercury in a condensing system. At some mines, beneficiation of ore prior to roasting has been practiced. For example, at the nearby Bretz Mine, a flotation mill was reportedly constructed in 1956 to concentrate the ore minerals prior to shipment to the ore processing facility at the Opalite Mine. (Brooks 1963)

In general, roasting of mercury ore is done in either furnaces or retorts. Furnaces are typically used where relatively large quantities of ore are available. A furnace was constructed at the Opalite Mine in 1926 to process the ore recovered from the Opalite Mine as well as ore concentrates transported by truck from the nearby Bretz Mine. The furnace was 5 feet in diameter and 70 feet long, and could process 80 to 100 tons of ore per day (Brooks 1963).

Rotary furnaces such as the one formerly used at the Opalite Mine consist of a tubular steel shell lined with firebrick or other refractory material mounted on a slope of between approximately 4% and 13%. Ore is fed continuously into the upper end of the furnace, which is heated by an oil burner at the lower end of the furnace. As the furnace rotates, ore moves downward to the lower end and is discharged. The mercury is released from the ore as the ore moves downward toward the lower end of the furnace. The resulting mercury vapor, along with combustion gases and dust, is drawn from the upper end of the furnace by a fan. A condensing system, consisting of a dust collector, condenser pipes, and suction fan, is located at the upper end of the furnace to condense and collect the elemental mercury. The mercury is condensed and collected in a series of vertical pipes joined at the top and bottom alternately with U-shaped connections. (Brooks 1963).

The Opalite Mine produced a total of 12,367 flasks of mercury (a flask is equivalent to 76 pounds) between 1927 and 1961, with the vast majority of the production occurring before 1943. Only spotty production was recorded between 1944 and 1961 (Brooks 1971).

3.4 Mercury in Mine Wastes

Based on historical information on geology and mineralogy of the Opalite Mine (Section 3.2), native mercury species at the Opalite Mine include cinnabar (HgS), elemental mercury (Hg^0) and the relatively rare oxychlorides, including terlinguaite (Hg_2ClO). These species may therefore be present in

unprocessed ore, waste rock, and soil/rock in the Open Pit/Glory Hole and other areas of the site with naturally occurring mercury mineralization.

As discussed in Section 3.3, mercury ore was thermally processed in a furnace located in the Ore Processing Area at the Opalite Mine. Historical information regarding the forms of mercury that may be present in the processed ore (burned ore) is not available. However, in general, extended X-ray adsorption fine structure (EXAFS) spectroscopy studies of mercury mine wastes indicate that the mercury species metacinnabar (m-HgS), corderoite ($Hg_3S_2Cl_2$), schuetteite ($HgSO_4$-H_20), and mercury chlorides are likely to form during the thermal processing of mercury ores (Rytuba 2002).

3.5 Mercury Speciation

In addition to the total concentration of mercury present in mine wastes and contaminated environmental media, information on the proportions of various mercury chemical/mineralogical species in these media may be used to better understand the fate and transport of mercury in the environment and to inform evaluations of risk to human and ecological receptors. For example, the speciation of mercury may be used to estimate the amount of mercury that is bioavailable when the exposure pathway is through direct ingestion or inhalation. The speciation of mercury phases also affects the amount of mercury that is released from wastes and that becomes available for methylation and subsequent incorporation into biota as methylmercury. Methylmercury is the most bioavailable form of mercury. Methylation of mercury and its uptake is a complicated process governed by several variables.

Information on the presence of various forms of mercury and other minerals in native materials (e.g., ore and waste rock) found in historical documents is summarized in Sections 3.2 and 3.4. Information on the forms of mercury commonly present in thermally processed mercury ore is summarized in Section 3.4.

The presence of various mineral species in native materials and mine wastes also may be evaluated directly using other modern laboratory techniques such as EXAFS spectroscopy, or indirectly using laboratory methods such as selective sequential extraction (SSE). Although the SSE technique does not identify the specific mineral phases or oxidation states of mercury, it does differentiate between and quantify groups of mercury species based upon solubility and may be useful for inferring which mercury species may be present. A mercury SSE technique has been used to assess mine wastes at the Opalite Mine as part of a previous investigation and the present removal assessment. Results are discussed in Sections 3.6 and 5.6.3 below.

3.6 Previous Investigations

Previous investigations at the Opalite Mine include a Preliminary Assessment conducted in June 2000 by ODEQ (2001), a Site Inspection conducted by Weston Solutions for the EPA in 2002 (Weston 2003), an assessment of mine-related impacts to macroinvertebrate communities in nearby creeks by ODEQ in 2004, and a Site Investigation (SI) conducted by E & E for ODEQ in 2003 and 2004 (E & E 2005).

Potential contaminant sources identified by previous investigations are:

- **Ore Processing Area.** Includes the dilapidated remains of a former rotary furnace and condenser system located in the Ore Processing Area. The furnace is no longer present. Several concrete structures that apparently were associated with the former furnace and associated condenser system, and broken pieces of ceramic pipe apparently associated with the condenser system are present.

- **Northern and Southern Burned Ore Piles.** Two large burned ore piles are located on either side of the Ore Processing Facilities. The total volume of both is estimated to be 192,384 cubic yards.
- **Underground Mine Workings.** Multiple shafts, adits/tunnels and other underground workings are present.
- **Waste Rock.** Waste rock piles, including piles in the vicinity of the portals of #1 Adit and #2 Adit (referred to as the #1 Adit and #2 Adit Waste Rock Piles in this report) and the Waste Rock Dump.
- **Open Pit/Glory Hole.** A large open pit containing exposed mineralized material.

The objectives and results of the previous investigations are summarized below.

ODEQ Preliminary Assessment (2000)

ODEQ conducted a site visit on June 6, 2000 and collected three soil samples and one sediment sample. The samples were analyzed for total mercury. Soil sample results were compared to EPA Region 9 PRGs (November 2000) for residential and industrial and Oregon Level II Ecological Screening Benchmark for Terrestrial Receptors (1998) for plants and invertebrates. The sediment sample results were compared to National Oceanic and Atmospheric Administration (NOAA) Screening Quick Reference Table (SQuiRT) (1999) values for freshwater sediments. The Preliminary Assessment evaluated targets for the four pathways to evaluate eligibility for potential placement on the National Priorities List. The report summarized that human receptors included occasional site visitors and workers performing mineral exploration activities and ecological receptors includes Lahontan Cutthroat trout (Federal-listed threatened species) present in McDermitt Creek 3 miles downstream of the site. Although the possibility of acid rock drainage was evaluated during the ODEQ investigation, its presence was not noted in the field (ODEQ 2001).

EPA Site Inspection (2002)

Weston Solutions conducted a Site Inspection for EPA in 2002. During the investigation, soil samples were collected from the Burned Ore Piles (four samples), the ore processing facility (four samples), the open pit (one sample), the #1 Adit (one sample), and one background location (one sample). Sample results were compared to background. In addition, four sediment samples were collected from Mine Creek downgradient of the site and one background location. (Weston 2003)

Assessment of Opalite Mine on Macroinvertebrate Communities of Mine, Hot and McDermitt Creeks (2004)

The ODEQ Watershed Assessment Division conducted an assessment of the benthic community of the Mine, Hot, and McDermitt creeks. To assess the impact on the benthic community a set of six sites were sampled upstream, downstream, and in the Cottonwood Creek watershed, located east of the Opalite Mine site. The primary objective was to document the macroinvertebrate community composition to assess potential biological impairment due to impacts from the mine. Lahontan Cutthroat trout occur in the McDermitt Creek drainage and are listed as sensitive by the Oregon Department of Fish and Wildlife. Chemical water quality samples were also collected as part of this assessment. Study results indicated that impacts from the Opalite Mine exist in Mine, Hot, and McDermitt Creeks. It was stated that, although the River Invertebrate Prediction and Classification System (RIVPACS) model does not seem to indicate biotic impairment due to loss of taxa, the temperature and sediment and metals diagnostic stressor tools indicate that there has

been a noticeable shift in community structure that clearly implicates degraded biotic integrity which is caused by temperature, fine sediment pollution, and the presence of toxic metals. It was concluded that improvement in both stream habitat and toxic run-off from the mine would be beneficial to the benthic communities of Mine, Hot, and McDermitt Creeks. (ODEQ 2004)

ODEQ Opalite Mine Site Investigation (2003-2004)

In 2003 and 2004, E & E performed a Site Investigation (SI) for ODEQ. During the SI, surface soil, surface water, sediment, road material, and fish tissue samples were collected. Two samples were collected from the Glory Hole/open pit, and four samples were collected from waste rock.

In addition to field screening and laboratory analysis for total metals, selected samples also were analyzed for methylmercury, mercury SSE, synthetic precipitation leaching procedure (SPLP), acid generating potential, and arsenic speciation.

A mercury SSE technique was employed as part of the SI to approximate relative proportions of mercury species based on solubility behavior. A five-step SSE technique was used to quantify the mercury present as water soluble, stomach acid (weak acid) soluble, organo-complexed (also referred to as organo-chelated), strong complexed (also referred to as elemental mercury), and mineral bound forms of mercury. A summary of the SSE technique used as part of the 2004-2004 investigation, and typical mercury species that are accounted for by each extraction step, is provided below.

Extraction Step	Extractant	Fraction Description	Typical Species
1	De-ionized Water	Water soluble	$HgCl_2$, $HgSO_4$ (salts)
2	pH 2 HCl/HOAc	Stomach acid soluble (weak acid)	HgO (mercuric oxide)
3	1M KOH	Organo-complexed (also referred to as Organo-chelated)	CH_3Hg, Hg-humics, Hg_2Cl_2
4	12 M HNO_3	Strong Complexed (also referred to as Elemental mercury)	Hg^0 (liquid elemental), Hg_2Cl_2
5	Aqua Regia (concentrated HCl and HNO_3)	Mineral bound (also referred to as Mercuric sulfide)	HgS, m-HgS, HgSe, HgAu

Key:

CH_3Hg = Methylmercury
HCl = Hydrochloric acid
Hg = Mercury
Hg^0 = Elemental mercury
HgAu = Mercury-gold amalgam
$HgCl_2$ = Mercuric chloride
Hg_2Cl_2 = Mercurous chloride
HgO = Mercuric oxide
HgS = Cinnabar
HgSe = Mercuric selenide
$HgSO_4$ = Mercuric sulfate
HNO_3 = Nitric acid
HOAc = Acetic Acid
KOH = Potassium hydroxide
m-HgS = Metacinnabar

Surface samples of source materials from the glory hole (GH01), ore processing area (OP18), waste rock dump (DP03), waste rock piles (WR01 and WR05), and burned ore piles (NP03 and SP05), and a

downgradient sediment sample (CC01), were analyzed for mercury SSE. Results indicated that between approximately 86.9% and 99.9% of the total mercury in the source samples and the Cowboy Creek sediment sample can be characterized as strong complexed or mineral bound fractions. Between 0.1% and 13.1% of the total mercury in the samples was in the comparatively soluble water soluble, stomach acid extractable, and organo-complexed forms.

Selected sediment samples from the SI (CT01, MT02, HC01, and MC02) were analyzed for mercury SSE. In sediment samples from MC02 and CT01, 75% and 88%, respectively, was in the mineral bound form, with organo-complexed and strong complexed forms comprising most of the rest of the mercury. For the samples from MT02 and HC01, 60% and 63%, respectively, was in the comparatively soluble organo-complexed form, with less soluble strong complexed and mineral bound forms comprising most of the rest of the mercury.

Results of the SI and previous investigations indicated on-site metals contamination over a broad area, including the Glory Hole, Ore Processing Area, Burned Ore Piles, waste rock piles, and waste rock dump. Results also indicate that on-site metals contamination may be impacting downgradient surface water, sediment, and fish. Contaminants of potential concern (COPCs) that may pose a risk to human health include antimony, arsenic, and mercury in site sources, and organic arsenic, arsenic (III), chromium, lead, and mercury in fish. Compounds of potential ecological concern (CPECs) in site sources that may pose a risk to ecological receptors include, aluminum, antimony, arsenic, barium, chromium, iron, mercury, nickel, vanadium, and zinc. CPECs identified in sediment include arsenic, cadmium, mercury, nickel, selenium, and zinc. CPECs identified in surface water include arsenic, cadmium, mercury, nickel, selenium, vanadium, and zinc.

No interim removal action measures to address the metals contamination were recommended at the time of report publication. The broad area over which COPCs and CPECs are located would require a major removal effort based on comparison of sample results to screening levels alone. There was insufficient information to establish site-specific, risk-based cleanup levels. Background metals concentrations were not well characterized, and the risks posed by site-related COPCs/CPECs was not adequately assessed. It was recommended that risk to human health be further evaluated in order to support risk management decisions. (E & E 2005)

McDermitt and Cordero Mercury Mine Sites Removal Action (2013)

In 2013, EPA's Region 9 removal program removed about 10,000 tons of mercury-contaminated material from 56 homes and a school and capped about 100,000 square feet of roadways and other areas in McDermitt, Nevada. Several of the homes where contaminated material was removed were located in Oregon. Much of the material was reported by EPA as having originated from the Cordero Mine in Nevada. However, observations made during the McDermitt/Cordero removal action suggest that material could have come from Opalite Mine as well as one of the other three local mercury mines (Bretz Mine in Oregon, and Cordero and McDermitt Mines in Nevada). All four mines are part of the Opalite mercury district (E & E 2013, ODEQ 2016, EPA 2017).

As part of the removal action in the town of McDermitt, the responsible parties for Cordero and McDermitt Mines addressed security at those sites. In addition, at the Bretz Mine, the Bureau of Land Management installed fences, signs, and capped the most contaminated material. Of the four mines in the Opalite mercury district, Opalite Mine remains the last that is unsecured (E & E 2013, ODEQ 2016, EPA 2017).

ODEQ Site Visit (2014)

ODEQ visited the site in 2014 and took photographs to document the then-current site conditions. The site was open to the public with no physical access restrictions (e.g., fences or gates). ODEQ photographed several of the posted warning signs and determined that maintenance was required to update degraded signage. ODEQ observed areas of the Northern and Southern Burned Ore Piles that appeared to have been recently disturbed near the ground surface, which could be the result of the public removing burned ore from the site, possibly for use as fill material. ODEQ requested that EPA investigate the site for potential threats to human health and the environment. (ODEQ 2014; 2016)

Summary of Previous Data

Data from the 2000 ODEQ Preliminary Assessment, the 2002 EPA Site Inspection, and the 2003-2004 ODEQ SI were compiled in the and summarized in Tables 1 through 3, described below. These data summary tables focus on the primary contaminants – mercury, arsenic, and antimony – and include both fixed laboratory results as well as X-ray fluorescence (XRF) field screening results for mercury, arsenic, and antimony and Lumex field screening results for mercury.

Table 1 presents field screening and laboratory analytical results of all historical soil/mine waste samples. Table 2 presents a summary analysis of historical soil/mine waste samples, organized by site sub-areas. Table 3 presents a summary of historical sediment samples from Mine Creek and other nearby streams.

In Tables 1 and 2, total mercury, arsenic, and antimony results are compared to current soil screening levels, including EPA Regional Screening Levels (RSLs; May 2016) and Removal Management Levels (RMLs; May 2016) for residential and industrial exposure. The RSLs are based on a hazard quotient of 1 for non-carcinogens and a target cancer risk of $1x10^{-6}$ for carcinogens. The RMLs are based on a hazard quotient of 3 for non-carcinogens and a target cancer risk of $1x10^{-4}$ for carcinogens. For mercury, the RSL and RML values are for elemental mercury, which are more conservative than the RSLs for mercury chloride and other mercury salts. For arsenic and antimony, the RSL and RML values are for inorganic arsenic and metallic antimony, respectively. Across these three investigations, total mercury was detected at a maximum laboratory concentration of 792 milligrams per kilogram (mg/kg), and 11 laboratory sample results exceeded the RML for industrial soil of 140 mg/kg. Arsenic was detected at a maximum laboratory concentration of 1,700 mg/kg, and 11 laboratory sample results exceeded the RML for industrial soil of 300 mg/kg. Antimony was detected at a maximum XRF concentration of 1,578 mg/kg, which also exceeded the RML for industrial soil of 1,400 mg/kg.

Sediment results for mercury, arsenic, and antimony are summarized in Table 3 and are compared to the consensus-based threshold effects concentrations (TECs) presented in MacDonald et al. (2000). Mercury was detected in sediment downgradient from the site as high as 110 mg/kg, three orders of magnitude higher than the TEC of 0.18 mg/kg. Arsenic was detected in sediment downgradient from the site as high as 34.7 mg/kg, which exceeds the TEC of 9.79 mg/kg. Antimony was detected in downgradient sediments as high as 8.45 mg/kg, which exceeds the sediment quality standard for the Pacific Northwest (0.3 mg/kg; Avocet 2011); no TEC value for antimony is provided in Macdonald et al. (2000).

4. PERSONS INVOLVED

Agency/Company	Contact Persons/ Position	Phone Number
EPA	Michael Boykin – On-Scene Coordinator (OSC)	206-553-6362
	Brooks Stanfield – OSC	206-553-4423
EQM / ERRS	Joe Ficek – Response Manager	425-673-2900
E & E / START	Steven Hall – Project Manager	206-624-9537
	Mark Longtine – Lead Geologist	206-624-9537
	Howard Edwards – Field Chemist	415-398-5326
	Manique Talaia-Murray – Site Safety Officer	206-624-9537
ODEQ	Bryn Thoms – ODEQ Project Manager, Geologist	541-686-7838

5. ACTIVITIES

5.1 Removal Assessment Objectives

Based on a review of historical operations and results of previous investigations at the Opalite Mine (Section 3), key removal assessment objectives were identified. These objectives and the activities performed to meet the objectives are briefly described:

- Assess potential risks to site visitors posed by ambient mercury vapor concentrations at the site through mercury vapor screening with a Jerome J505 mercury vapor analyzer.
- Assess surface and subsurface soil in the Ore Processing Area for potential sources of elemental mercury through:
  - In situ XRF field screening of surface soils.
  - XRF field screening of surface and subsurface soils samples collected during test pit excavation.
  - Mercury vapor screening with a Jerome J505 mercury vapor analyzer.
  - Collection of selected samples for mercury SSE analysis.
- Assess surface and subsurface soils in areas of suspected high levels of total mercury, arsenic, and antimony through:
  - In situ XRF field screening of surface soils.
  - XRF field screening of surface and subsurface soils samples collected during test pit excavation.

  - Laboratory analysis of a subset of samples for total metals analysis for mercury, arsenic, and antimony.
- Assess potential variability with depth of concentrations of mercury, arsenic, and antimony in the Northern and Southern Burned Ore Piles through XRF field screening of surface and subsurface soils samples collected during test pit excavation.
- Identify and assess possible overland drainage pathways to evaluate potential off-site migration of contaminants to surface water bodies through visual observations and in situ XRF field screening.
- Assess surface soil in other site areas for concentrations of mercury, arsenic, and antimony to inform the evaluation of potential risk to site visitors and off-site migration through in situ XRF field screening.
- Assess road access to the site to evaluate possible on-site public access controls (e.g., gates or fencing) through visual observation.
- Assess the Northern and Southern Burned Ore Piles for evidence of possible disturbance and removal of materials for use off-site (e.g., as fill) by the public through visual observation.

Field activities that were performed to achieve these objectives are discussed in detail in Sections 5.2 through 5.7. The field activities were performed in accordance with a site-specific sampling plan (E & E 2016).

5.2 Mobilization

EPA, ERRS, and START mobilized to the vicinity of the site on August 8, 2016 and split into two groups. A group composed of EPA, ERRS, and one START team member visited Opalite Mine to assess the quality of mine access roads and to stage the excavator in preparation for the following day's activities. Three START field team members secured equipment and procured supplies to support field operations. On August 9, the entire removal assessment team mobilized to the site to complete the removal assessment and were joined by Bryn Toms of ODEQ.

5.3 Health and Safety Briefing and Site Reconnaissance

Upon arrival at the site on August 9, EPA, START, and ERRS participated in a tailgate meeting to discuss on-site health and safety concerns. Key topics discussed included safety precautions during test pit excavation, ambient air screening for mercury vapor, and site emergency procedures.

Following the health and safety meeting, START members accompanied the OSCs and ODEQ on a site reconnaissance walk to finalize the preliminary removal assessment objectives and the sampling approach.

5.4 Ambient Air Monitoring

START monitored ambient air for elemental mercury continuously during the August 9 field activities. The objectives of the monitoring were twofold: first, to assess potential health and safety risk to the field team posed by mercury vapor; and second, to assess the potential risk posed by the site to the public by mercury vapor or dust. Results of the ambient air monitoring were for measurements taken prior to test pit excavation. See Section 5.5.2 for a discussion of air monitoring for mercury vapor and potentially arsenic-bearing particulate matter during test pit excavation.

START used a Jerome J505 to screen for mercury vapors. A calibration check of this instrument was performed in the personnel and vehicle staging area southwest of the Northern Burned Ore Pile. Following instrument calibration, START screened ambient concentrations of mercury vapor in air in the vicinity of selected key site features. Discrete measurements were collected at relatively small site features (e.g., at the portal of #2 Adit) as well as at larger site features (e.g., near piles of waste rock). Each discrete measurement location was photographed and marked on a site map. START also screened the air continuously between each discrete measurement location. Additional ambient mercury vapor screening was performed in the Ore Processing Area prior to test pit excavation.

Ambient mercury vapor concentrations near key site features and in the Ore Processing Area prior to test pit excavation were compared to the Agency for Toxic Substances and Disease Registry (ATSDR) guidance level of 10 micrograms per cubic meter ($\mu g/m^3$) for "workers not covered by a health and safety program addressing exposure to mercury." This value was chosen because research indicates that 10 $\mu g/m^3$ may be the lowest concentration toxic to humans, and this ATSDR category is also is the closest designation that aligns with a recreational or occasional-use visitor scenario (ATSDR 2012). Measurement locations and results are presented in Figures 3 and 4 and are discussed in Section 5.4.1 below.

5.4.1 Ambient Air Monitoring Results

Results of ambient mercury vapor screening near key site features outside of the Ore Processing Area ranged from 0.03 $\mu g/m^3$ northeast of the #1 Adit to 0.2 $\mu g/m^3$ in the Glory Hole (Figure 3). These values were substantially less than the ATSDR guidance level for mercury vapor. In the Ore Processing Area (Figure 4), the maximum ambient mercury vapor concentration was 2.0 $\mu g/m^3$. In general, readings were higher in the Ore Processing Area than at other site features.

5.5 Test Pit Excavation

5.5.1 Test Pit Description

Eight test pits were excavated during the course of the August 9 field activities at the locations shown in Figure 5. Test Pits 1 through 3 were excavated to assess the concentrations of metals in the area extending northeast of the Ore Processing Area. Test Pits 4 through 6 were excavated to characterize the waste materials and soil near the remnants of the former furnace. Test Pits 7 and 8 were excavated at the Northern and Southern Burned Ore Piles, respectively, to assess whether contaminant concentrations within the subsurface material varied from those at the ore pile surface.

Lithological observations of excavated materials and other geologic observations were used in conjunction with information about the historical mining and ore processing activities and facilities and results of continuous air monitoring (Section 5.5.2) and XRF screening (Section 5.5.3) to identify mine waste, native soil, and bedrock. The observations and interpretations were logged for excavated depth intervals in the START logbook. Photographic documentation is presented in the photographic log (Attachment 1).

Selected samples were collected during test pit excavation for laboratory analysis of total metals mercury, arsenic, and antimony and mercury SSE. Selected samples and laboratory analyses are identified in Table 4. Section 5.6 presents a discussion of the laboratory sample selection process and analytical results. Table 5 presents a summary of XRF and laboratory analytical results, mercury vapor screening results, and lithologic descriptions.

5.5.2 Test Pit Air Monitoring

During test pit excavation, START conducted continuous mercury vapor screening with the Jerome J505 of the personnel breathing zone as well as discrete measurements of mercury vapors of the excavated material, and from within or near the edge of the test pits pit as excavation progressed. Readings were logged digitally in the Jerome J505 unit and written in the START logbook. Results of this mercury vapor screening are presented in Table 5 and discussed below.

Mercury vapor readings recorded during test pit excavation in the personnel breathing zone, the excavated material, and within the test pits were compared to the American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit value (TLV) for mercury (25 µg/m^3), a level which is based on exposure estimates for normal occupancy in an industrial setting when mercury exposure is expected in normal course of work (ATSDR 2012).

During continuous screening in each monitored zone and test pit interval, START observed that the elemental mercury values consistently dropped rapidly after the initial readings as the elemental mercury in the material dispersed upon exposure to air. Based on this trend, site conditions, and the minimal exposure of field personnel to elemental mercury in the breathing zone, the TLV was determined to be a sufficiently conservative comparison value. Mercury vapor screening results compared to the TLV are presented in Table 5. A single exceedance of the TLV during mercury vapor screening in the personnel breathing zone occurred while excavating the deepest interval of Test Pit 6 (73.6 µg/m^3; 8 feet below ground surface [bgs]). This value was four times greater than the next highest breathing zone mercury vapor result (18 µg/m^3), measured during excavation of Test Pit 1 at 3.5 feet bgs.

The highest mercury vapor results from screening of the excavated material and the test pits were measured at Test Pit 6. Results from the excavated material ranged from 48 µg/m^3 (7 feet bgs) to greater than 500 µg/m^3 (6 feet bgs), which is the upper limit of the Jerome J505 detection range. Measurements taken from within Test Pit 6 ranged from 167 µg/m^3 (3 feet bgs) to 273 µg/m^3 (4 feet bgs). The excavated material from Test Pit 6 at 6 feet bgs and deeper was described as fill consisting of tan to dark brown sand, chunks of brick, wood, and concrete.

The TLV was also exceeded when screening the excavated material from Test Pit 1 (33 µg/m^3; 4.5 feet bgs); Test Pit 2 (43 µg/m^3; 2.5 feet bgs); and Test Pit 4 (33 µg/m^3; 3.5 feet bgs). During direct screening within the test pits, the TLV was exceeded in Test Pit 1 at 2.5 feet bgs (60 µg/m^3) and 3.5 feet bgs (40 µg/m^3); and in Test Pit 2 (90 µg/m^3; 2.5 feet bgs). The material from each of these intervals was described as weathered bedrock consisting of finely layered silty sands.

A DataRAM and a Personal DataRAM were used to monitor personnel exposure to potentially arsenic-bearing particulates during test pit excavation. The instruments were zeroed in the staging area, brought to the Ore Processing Area, and placed near the field team member's positions, which were upwind of excavation activities. Particulate monitoring results are discussed below.

After 7.5 hours of runtime with the DataRAM, the time-weighted average (TWA) particulate matter concentration was 17.4 µg/m^3. The REL for airborne arsenic is 2 µg/m^3, which would apply if the airborne particulate matter was composed entirely of arsenic. Based on historical analytical data for total arsenic concentrations in soil at the Opalite Mine, a site-specific exposure limit of 600 µg/m^3 was calculated. To make this site-specific exposure limit as conservative as possible, the greatest historical analytical result (1,700 mg/kg; Southern Burned Ore Pile) was used in conjunction with a safety factor of 2. The TWA of 17.4 µg/m^3 was well below the calculated site-specific exposure limit for arsenic-containing particulate matter.

5.5.3 Test Pit XRF Screening

Material from each excavated test pit interval was screened for metals using the EPA Region 10 field-portable XRF (Olympus Delta DPO-4000) or ODEQ XRF (Innov-X Alpha Series). In conjunction with mercury vapor screening results and geological observations, XRF field screening results were used to guide the selection of samples for additional XRF screening and off-site laboratory analysis.

The laboratory analyses and results are discussed in Section 5.6, and additional information on ex situ XRF analyses of the test pit samples are discussed in Section 5.6.2.

5.6 Soil and Mine Waste Material Sampling and Laboratory Analysis

START collected a total of 20 primary and two field duplicates samples for off-site analyses. The sample locations and selected analyses are summarized in Table 4, and the sample locations are illustrated on Figure 5. Nineteen samples were collected from test pit intervals that represented a range of soil and mine waste types found during excavation in the Ore Processing Area and Northern and Southern Burned Ore Piles. XRF screening values also were used to guide selection of samples for laboratory analysis, with samples selected to represent a relatively broad range of metals concentrations. The twentieth sample (OP01SS0.5) was collected from a pile of grey silty material at the surface in the southeastern part of the Ore Processing Area. Material selected for laboratory analysis was placed in a dedicated plastic bag, homogenized, and screened once more with the XRF (i.e., ex situ screening).

Twenty primary samples and two field duplicates were shipped to A&B Labs in Houston, Texas for the following analyses:

- Total Mercury, SW-846 Method 7471B
- Total Arsenic and Antimony, SW-846 6010D

Four of these samples were also shipped to Eurofins Frontier Global Sciences, Inc. in Bothell, Washington for mercury SSE.

Off-site analytical laboratory results were validated by a START chemist. Data validation memoranda are presented in Attachment 2.

5.6.1 Laboratory Total Metals Results

Table 5 presents the results of laboratory analysis for total antimony, arsenic, and mercury analysis for the soil and mine waste samples.

Across the sample results from the Ore Processing Area and Northern and Southern Burned Ore Piles, total mercury was detected at a maximum concentration of 5,360 mg/kg in Test Pit 6, and 12 primary sample results exceeded the mercury RML for industrial soil of 140 mg/kg. The only test pits from which samples did not exceed the industrial soil RML were Test Pit 7 (Southern Burned Ore Pile) and Test Pit 8 (Northern Burned Ore Pile). The greatest exceedances of the RML for mercury were in Test Pit 6. Of the five intervals sampled, four exceeded the industrial soil RML of 140 mg/kg, and three of these exceeded it by an order of magnitude: 4,580 mg/kg at 3 feet bgs, 2,520 mg/kg at 7 feet bgs, and 5,360 mg/kg at 8 feet bgs. Nineteen of the 20 primary samples also exceeded the mercury RSL for industrial soil (46 mg/kg).

The maximum concentration of total arsenic was detected at 670 mg/kg in sample TP06SB20 (duplicate of sample TP06SB03) from Test Pit 6. Arsenic was detected in a total of three samples from Test Pit 6 (TP06SB20 and primary samples TP06SB03 and TP06SB04) at concentrations that exceeded the RML for industrial soil (300 mg/kg). The RML was also exceeded in one sample from Test Pit 7 (TP07SB05) at the Southern Burned Ore Pile. Total arsenic was detected in all 20 of the primary samples at concentrations greater than the EPA RSL for industrial soil (3 mg/kg).

Total antimony concentrations for the 20 primary samples did not exceed the RSL (470 mg/kg) or RML (1,400 mg/kg) for industrial soil.

5.6.2 Laboratory Results-XRF Correlation

During excavation of each test pit, a soil sample was collected from each interval (except Test Pit 1, from which no samples were collected) in a re-sealable plastic bag for ex situ XRF screening by START and potential laboratory analysis. Table 5 presents the ex situ EPA XRF screening results for mercury, arsenic, and antimony for the sampled intervals. Table 5 also presents the laboratory analytical results for total mercury, arsenic, and antimony for the corresponding laboratory samples.

A correlation between the laboratory and the ex situ XRF results was performed for mercury, arsenic, and antimony. The correlation coefficient (r) for the mercury sample pairs is 0.775, which is greater than the minimum correlation of 0.7 for screening level data, but less than the minimum 0.9 correlation coefficient criterion for definitive level data, as described in EPA Method 6200 (Field Portable XRF). Therefore, based on this data set, an XRF could be used to screen ex-situ soil samples for mercury, but the resulting data would not meet definitive level data criteria and would likely need to be corroborated with additional confirmation sampling. The calculated r values for arsenic and antimony are 0.959 and 0.937, respectively, both of which are greater than 0.9. On the basis of these calculated correlation values, the XRF data for arsenic and antimony for the prepared ex-situ samples could potentially meet definitive level data criteria (EPA 2013). It is noted, however, that correction factors would need to be applied to correct for non-zero y-intercepts and slope values significantly different from one.

5.6.3 Mercury SSE Results

Selected samples of soil/tailings from the test pits and Ore Processing Area were analyzed by Eurofins Frontier Global Sciences, Inc. using a mercury SSE technique to provide information that may be used to evaluate the potential mobility, bioavailability, and chemical forms of mercury in selected materials at the site. Mercury SSE is a non-standard analysis that entails the sequential extraction of mercury from the same sample aliquot through a sequence of different extractants of increasing chemical strength and analyzing the amount of total mercury extracted in each step of the sequence. For the present removal assessment, Eurofins Frontier Global Sciences, Inc. used a seven-step process to generate seven separate mercury fractions, referred to as Fraction 0 (F0) through Fraction 6 (F6). The amount of mercury extracted at each step was quantified using EPA Method 1631. In addition, to assess potential sample heterogeneity, a separate aliquot of the sample analyzed for mercury SSE also was analyzed for total mercury, also by EPA Method 1631. A detailed description of the mercury SSE method and guidance on interpretation of results are provided in Attachment 3. Table 6 presents a general description of the extractants and typical mercury species extracted for each SSE fraction. Results of the mercury SSE analyses of the removal assessment samples also are presented in Table 6. Key observations of the results are summarized below.

Burned Ore

The two samples of burned ore (TP07SB05 and TP08SB05) contained comparatively low concentrations of total mercury, with a maximum concentration of 152.5 mg/kg (sum of SSE fractions F0 through F6), and most concentrations below the RML for industrial soil (140 mg/kg). The proportions of the total mercury detected in the minimally soluble F5 and F6 fractions are 86 and 85 percent, respectively. These fractions likely represent predominantly cinnabar from the original ore that was not thermally decomposed as part of the ore processing. The amounts of total mercury detected in the comparably more mobile and bioavailable fractions F0 through F4 are 13 mg/kg and 23 mg/kg, respectively. These combined fractions are well below the RSL for industrial soil (46 mg/kg).

Soil in the Ore Processing Area

Sample TP06SB06 was collected from a depth of 6 feet in fill materials adjacent to the remains of an ore processing structure. The sample contained total mercury at a concentration of 2,200 mg/kg (separate aliquot, EPA Method 1631). The sum of the SSE fractions F0 through F6 is similar (2,615.4 mg/kg). Only 38 percent of the sum of fractions F0 through F6 was detected in fractions F5 and F6. The remaining 1,623 mg/kg was detected in fractions F0 through F4. A total of 670 mg/kg was detected in the comparatively mobile F1 (water soluble) and F2 (weak acid soluble) fractions. The result of the F3 fraction is 131 mg/kg. Although the mercury SSE method does not allow for the identification of specific mercury compounds in these fractions, based on general information regarding products of thermal processing of mercury ore (Rytuba 2002), fractions F1 through F3 likely include some proportions of $HgCl_2$, $HgSO_4$, HgO, and Hg_2Cl_2. The fraction F4 result was 764 mg/kg. In general, fraction F4 may include elemental mercury, although interpretation of the F4 results may be complicated (see Attachment 3). Considering the comparatively high F0 fraction result of 58.4 mg/kg, in conjunction with the relatively elevated mercury vapor screening results for Test Pit 6 (see Section 5.5.2), it is likely that a significant proportion of the F4 fraction in sample TP06SB06 consists of elemental mercury.

Gray Silty Material Adjacent to Ore Processing Area

Sample OP01SS0.5 was collected from the surface of a small pile of gray silty material adjacent to the road west of the Ore Processing Area. The nature of the material is not readily apparent, but it appears to be waste associated with the thermal ore processing. The SSE results are similar to those of sample TP06SB06. The sample contained total mercury at a concentration of 1,960 mg/kg (separate aliquot, EPA Method 1631). The sum of the SSE fractions F0 through F6 is similar (1,572 mg/kg). Only 35 percent of the sum of fractions F0 through F6 was detected in fractions F5 and F6. The remaining 1,019 mg/kg was detected in fractions F0 through F4. A total of 629 mg/kg was detected in the comparatively mobile F1 (water soluble) and F2 (weak acid soluble) fractions. The result of the F3 fraction is 168 mg/kg. As with sample TP06SB06, fractions F1 through F3 likely include some proportions of $HgCl_2$, $HgSO_4$, HgO, and Hg_2Cl_2. The fraction F4 result was 220 mg/kg. Considering the apparent association of the material with ore processing, is likely that a significant proportion of the F4 fraction consists of elemental mercury.

5.7 In-Situ Surface Soil XRF Field Screening

In situ XRF field screening was performed by START and ODEQ personnel to assess surface soils for mercury, arsenic and antimony concentrations. START used the EPA XRF to screen in situ surface soils at locations in the Ore Processing Area and other locations south of the Ore Processing Area. The in situ field screening southeast of the Ore Processing area targeted various accumulations of visibly different types of mine wastes. ODEQ personnel used the ODEQ-owned XRF to perform in situ screening along overland drainage pathways to assess potential migration of mercury, arsenic and antimony from source materials at the Northern and Southern Burned Ore Piles and Ore Processing Area toward nearby Mine

Creek. Screening locations were described in an EPA logbook and the XRF data were recorded in the START and ODEQ XRFs. Results of the in situ XRF field screening are described for each area in the sections below.

5.7.1 Ore Processing Area

Surficial materials in the Ore Processing area were screened in situ by START at locations adjacent to or near the remains of the former ore processing facilities and along the access road. Figure 6 displays the screening locations and screening results and Table 7 presents a summary of the results compared to EPA RSLs and RMLs.

In situ XRF screening values for mercury ranged from 30 ppm in the northeast to 3,418 ppm near the remains of the ore processing structures (location EPA-33). The second highest value of 1,862 ppm was from a screening location adjacent to the access road (location EPA-15). Except for some screening locations in the northeastern section of the Ore Processing Area, most screening results exceeded the RML for industrial soil.

In situ XRF screening values for arsenic ranged from 25.7 ppm in the northeast to 726 ppm near the remains of the ore processing structures (location EPA-33). Most arsenic screening results in the Ore Processing Area exceeded the RSL for industrial soil, and one exceeded the RML for industrial soil. The highest values were in the access road and near the remains of the ore processing structures.

In situ XRF screening values for antimony ranged from 22 ppm in the northeastern section to 345 ppm near the remains of the mine structures (EPA-39). None of the concentrations exceeded the RML or RSL for industrial soil.

5.7.2 Mine Waste Materials Southeast of the Ore Processing Area

Various mine wastes are present in piles located southeast of the Ore Processing Area and north of the Southern Burned Ore Pile. At least some of the mine wastes in this area appear to be burned ore based on their visual appearance and location near the discrete Southern Burned Ore Pile. Other mine wastes were not positively identified. These features had not been assessed during previous site investigations.

START performed in situ XRF screening for mercury, arsenic, and antimony at several piles/accumulations of mine wastes, selected in the field based on differences in color and areal distribution. In situ XRF screening locations are illustrated in Figure 6 and described in Table 7. Screening results for mercury, arsenic, and antimony are shown in Figure 6 and compared to EPA RMLs and RSLs in Table 7.

Screening concentrations of mercury in the pile of gray mine waste (locations EPA-43 through EPA-45) ranged from 474 to 916 ppm, exceeding the RML for industrial soil (140 mg/kg). Mercury concentrations in the white mine waste (locations EPA-53 and EPA-54) were 438 ppm and 1,290 ppm. Mercury concentrations in other materials ranged up to 139 ppm, with some exceeding the RSL for industrial soil (46 mg/kg) but none exceeding the RML for industrial soil.

Arsenic concentrations in each of the material types screened – gray mine waste, red mine waste, and white mine waste – significantly exceeded the industrial soil RML (300 mg/kg), with concentrations as high as 4,667 ppm (EPA-45). Most of the arsenic results were greater than the RML and all were greater than the RSL for industrial soil (3 mg/kg).

Antimony concentrations were greatest in the red mine waste (likely burned ore), including concentrations of 2,123 ppm (location EPA-49) and 1,748 ppm (location EPA-51) that exceeded the industrial soil RML (1,400 mg/kg). At least one screening location in each of the mine waste types screened exceeded the industrial RSL (470 mg/kg).

5.7.3 Glory Hole

ODEQ used its XRF to screen surface soil at two locations in the Glory Hole area. The screening locations are shown on Figure 7, and the results are summarized in Table 7. Mercury exceeded the industrial RML at both locations, with a maximum concentration of 1,263 ppm (screening location ODEQ-38). Arsenic exceeded the industrial RSL at both locations, with a maximum concentration of 160 ppm (ODEQ-38). Antimony was not detected above the industrial RSL or RML.

5.7.4 Overland Drainage Pathways

EPA and ODEQ performed a visual reconnaissance and in situ XRF field screening in selected areas located downgradient of the Northern Burned Ore Pile, Southern Burned Ore Pile, and a road leading to the mine. The field screening locations were visually determined to lie within possible overland drainage pathways between the mine sources and Mine Creek. EPA and ODEQ used the ODEQ XRF to screen surface soil for mercury, arsenic, and antimony. The screening locations are shown on Figure 7, and the results are summarized in Table 8.

Downgradient of Southern Ore Pile

The highest concentrations were detected at the selected locations downgradient of the Southern Ore Pile (locations ODEQ-27 through -32). One screening location immediately adjacent to the Southern Ore Pile (ODEQ-30) appeared to be a smaller pile of burned ore that had sloughed off the main pile, and XRF screening indicated that all three metals of concern exceeded the RSLs for industrial soil. Arsenic was detected at a concentration of 555 ppm, which also exceeded the RML for industrial soil (300 mg/kg), and antimony was detected at a concentration of 1,321 ppm, just below the RML for industrial soil (1,400 mg/kg). Results for locations further downgradient indicate exceedances of industrial RSL values for mercury and arsenic. No trend in concentrations is readily apparent.

Downgradient of Northern Ore Pile

At screening locations downgradient from the Northern Burned Ore Pile, mercury exceeded the industrial soil RSL at one location (ODEQ-25) and arsenic exceeded the industrial RSL at three locations (ODEQ-24, -25, and -26). Antimony was not detected at these locations.

Downgradient of Road Between Opalite Mine and Mine Creek

Seven locations (ODEQ-17 through -23) were screened in a dry wash between the road and Mine Creek. At the screening locations closest to the road (ODEQ-17 through -19), mercury was detected as high as 32 ppm (less than the industrial soil RSL), arsenic was detected as high as 49 ppm (greater than the industrial soil RSL), and antimony was not detected. At screening locations downgradient from the road (ODEQ-20 and -21), mercury was detected as high as 21 ppm (less than the industrial soil RSL), arsenic was detected as high as 39 ppm (greater than the industrial soil RSL), and antimony was not detected. The two screening locations closest to Mine Creek (ODEQ-22 and -23) were non-detect for mercury, arsenic, and antimony.

5.8 Demobilization

Upon completion of the excavation and investigation activities, equipment was decontaminated prior to leaving the exclusion zone. EPA, including the ERRS and START contractors, demobilized from the site on August 9.

6. SUMMARY AND CONCLUSIONS

EPA, along with its START and ERRS contractors, conducted a removal assessment with the assistance of ODEQ at the Opalite Mine Site in Malheur County, Oregon on August 9, 2016. Assessment activities included elemental mercury vapor screening of site features in ambient conditions; excavation of eight test pits in the Ore Processing Area and Northern and Southern Burned Ore Piles; collection of soil/waste material samples for laboratory analysis; and in situ XRF screening of site features. Twenty primary field samples were collected for analysis of total mercury, arsenic, antimony, with a subset of four submitted for mercury SSE analysis.

Ambient concentrations of mercury vapor near site features and in the Ore Processing area prior to test pit excavation were below the ATSDR guidance level (10 $\mu g/m^3$) for workers not covered by a health and safety program addressing exposure to mercury. The ambient mercury vapor concentrations were greater in the Ore Processing Area than for other site features. Mercury vapor concentrations were even greater when site materials were disturbed during test pit excavation in the Ore Processing Area.

The results of the test pit excavation in the Ore Processing Area indicated subsurface soil with concentrations of mercury, arsenic, and antimony greater than the RSL and RML values for industrial soil. All of the test pits in the Ore Processing Area (Test Pits 1 through 6) contained mercury at concentrations greater than the industrial soil RML and arsenic at concentrations greater than the industrial soil RSL. In Test Pit 6, mercury, arsenic, and antimony all exceeded their respective industrial soil RMLs. The highest concentrations were detected in Test Pit 6, which was located near a former ore processing structure. Test Pit 6 displayed high concentrations of total mercury throughout most of its excavated depths, with the greatest laboratory mercury concentration (5,360 mg/kg) from a sample collected at 8 feet bgs from fill consisting of burned wood, brick, and concrete. Mercury was also detected in the laboratory samples at concentrations of 4,580 mg/kg (3 feet bgs) and 2,520 mg/kg (7 feet bgs). Overall, the mercury concentrations in Test Pit 6 were much higher than the maximum concentration of mercury detected in the Ore Processing Area (253 mg/kg) from previous investigations. Visible elemental mercury was not observed during test pit excavation.

Four soil samples were analyzed using a mercury SSE technique to provide information that may be used to evaluate the potential mobility, bioavailability, and chemical forms of mercury in selected materials at the site. Two samples of burned ore contained comparatively low concentrations of total mercury, and most of the mercury was in the form of the minimally soluble F5 and F6 fractions. These fractions likely represent predominantly cinnabar from the original ore that was not thermally decomposed as part of the ore processing. The amounts of total mercury detected in the comparably more mobile and bioavailable fractions F0 through F4 were 13 mg/kg and 23 mg/kg, below the RSL for industrial soil (46 mg/kg). One sample collected from Test Pit 6 contained mercury at a concentration of 2,615.4 mg/kg (sum of the SSE fractions F0 through F6). Only 38 percent of the sum of fractions F0 through F6 was detected in fractions F5 and F6. The remaining 1,623 mg/kg was detected in fractions F0 through F4. A total of 670 mg/kg was detected in the comparatively mobile F1 (water soluble) and F2 (weak acid soluble) fractions. Based on a combination of general site information, the relatively elevated mercury vapor screening results for Test Pit 6, and the SSE results, it is likely that a significant proportion of the F4 fraction (764 mg/kg) in the sample consists of elemental mercury. One sample was collected from the surface of a small pile of gray silty material (possibly a waste product of thermal ore processing) adjacent to the road west of the

Ore Processing Area. The sum of the SSE fractions F0 through F6 is similar (1,572 mg/kg). Similar to the Test Pit 6 sample, only 35 percent of the sum of fractions F0 through F6 was detected in fractions F5 and F6. A total of 629 mg/kg was detected in the comparatively mobile F1 (water soluble) and F2 (weak acid soluble) fractions. Considering the apparent association of the material with ore processing, it is suspected that a significant proportion of the fraction F4 result (220 mg/kg) may consist of elemental mercury.

Southeast of the Ore Processing Area, an in situ XRF survey detected elevated concentrations of mercury, arsenic, and antimony in several waste rock piles that had not been characterized during previous site investigations. Concentrations of mercury and arsenic exceeded the industrial RML in the grey mine waste pile; values of arsenic in one screening location was as high as 4,667 ppm. The red mine waste pile showed elevated arsenic and antimony values that exceeded the RML for each metal, with a maximum arsenic value of 1,570 ppm and a maximum antimony value of 2,123 ppm. The white mine waste pile showed XRF readings of mercury and arsenic that exceeded the industrial soil RML; the maximum concentrations of mercury and arsenic were 1,290 ppm and 3,227 ppm, respectively.

The Northern and Southern Burned Ore Piles represent potential source areas for overland contamination transport via surface water migration. Although concentrations of mercury and arsenic generally decrease further away from the source areas, several screening locations downgradient of the site exceeded industrial soil RSLs for mercury and arsenic. These exceedances may be due in part to downgradient migration from one or more source areas. However, a site background soil study and additional sediment sampling would be necessary to better understand migration and potential impacts to Mine Creek and other streams.

Due to the site's remote location, access by the public would be difficult. The unpaved roads are in fair condition and would not prevent site access by the public. Several warning signs previously installed by ODEQ were present but were in degraded condition. However, no physical access restrictions (e.g., gates, fencing) were present at the site, and anecdotal evidence and field observations by ODEQ indicate that the public may be taking material from the unsecured tailings piles for construction or other aggregate uses. Opalite Mine remains the last unsecured mercury mine in the area and it was likely a source of some contaminated material that was removed or capped during an EPA Region 9 removal action in the nearby town in McDermitt, Nevada in 2013.

7. REFERENCES

Agency for Toxic Substances and Disease Registry (ATSDR), 2012, Chemical-Specific Health Consultation for Joint EPA/ATSDR National Mercury Cleanup Policy Workgroup, Action Levels for Mercury Spills, March 22, 2012.

Avocet Consulting, 2011, Development of Benthic SQVs for Freshwater Sediments in Washington, Oregon, and Idaho. Washington State Department of Ecology Publication No. 11-09-05.

Brooks, H.C., 1971, Quicksilver Deposits in Oregon, Miscellaneous Paper 15, Oregon Department of Geology and Mineral Industries, Portland, Oregon.

_____, 1963, Quicksilver in Oregon, Bulletin Number 55, Oregon Department of Geology and Mineral Industries, Portland, Oregon.

Ecology and Environment, Inc. (E & E), August 5, 2016, *Opalite Mine Site Removal Assessment, Site-Specific Sampling Plan*, prepared for the U.S. Environmental Protection Agency, Seattle, Washington, under Contract No. EP-S7-06-02, TDD No. 16-03-0008.

_____, July 2013, Removal Action Report, McDermitt and Fort McDermitt Paiute-Shoshone Reservation, Humboldt County, Nevada, and Malheur County, Oregon, Malheur County, Oregon, prepared for the U.S. Environmental Protection Agency, Emergency Response Section, Region 9, under TDD No. TO2-09-13-01-0003.

_____, February 2005, Final Opalite Mine Site Investigation Report, Malheur County, Oregon, prepared for ODEQ.

Gray, John E., Monique G. Adams, James G. Crock, and Peter M. Theodorakos. 1999. Geochemical Data for Environmental Studies of Mercury Mines in Nevada. U.S. Geological Survey Open-File Report 99-576.

Rytuba, James J., 2002, Mercury Geoenvironmental Models, in Progress on Geoenvironmental Models for Selected Mineral Deposit Types, Robert R. Seal II and Nora K. Foley, Editors, U.S. Geological Survey Open-File Report 02-195 Online Version 1.0. Accessed via the internet at: http://pubs.usgs.gov/of/2002/of02-195/OF-02-195-508-V5.pdf

MacDonald, D.D., Ingersoll, C. G., and Berger, T.A. (MacDonald et. al.), 2000, Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems, published in the Archives of Environmental Contamination and Toxicology, volume 39, pages 20-31.

Oregon Department of Environmental Quality (ODEQ) , July 29, 2016 , Removal Action Referral – Opalite Mine, Malheur County, Oregon CERCLIS #ORN001002255, ECSI #2491.

_____, 2014, Photographic presentation of July 2014 Opalite Mine Site Visit.

_____, October 11, 2004, Assessment of Opalite Mine on Macroinvertebrate Communities of Mine, Hot and McDermitt Creeks, Technical Report WAS04-002.

_____, March 12, 2001, Preliminary Assessment, Opalite Mine, prepared for US EPA.

Schuette, C.N., 1938, Quicksilver in Oregon, Bulletin Number 4, Oregon Department of Geology and Mineral Industries, Portland, Oregon.

United States Environmental Protection Agency, accessed on March 22, 2017, website for McDermitt and Cordero Mercury Mine Sites, https://response.epa.gov/mcdermitt.

_____May 2016, Regional Screening Levels for Chemical Contaminants at Superfund Sites. August 6, 2016. https://www.epa.gov/risk/regional-screening-levels-rsls.

_____, May 2016, Regional Removal Management Levels for Chemicals, August 6, 2016. https://www.epa.gov/risk/regional-screening-levels-rsls.

_____, 2013, Metals in Soil by X-Ray Fluorescence. Region 10 EMP Field Analytical Standard Operating Procedure 302 A, Rev. 1.

Weston Solutions, Inc. (Weston), March 5, 2003, Opalite Mine Site Inspection Report, prepared for US EPA.

Yates, R.G., 1942, Quicksilver deposits of the Opalite District, Malheur County, Oregon, and Humboldt County, Nevada, Strategic Minerals Investigations, 1941, U.S. Geological Survey Bulletin 931-N.

This page intentionally left blank.

Source: Maptech, Inc. 2001.

Opalite Mine Site

Mine Creek

Cowboy Creek

McDermit

Note: Southern edge of this map is the Oregon/Nevada state border.

ecology and environment, inc.
Global Environmental Specialists
Seattle, Washington

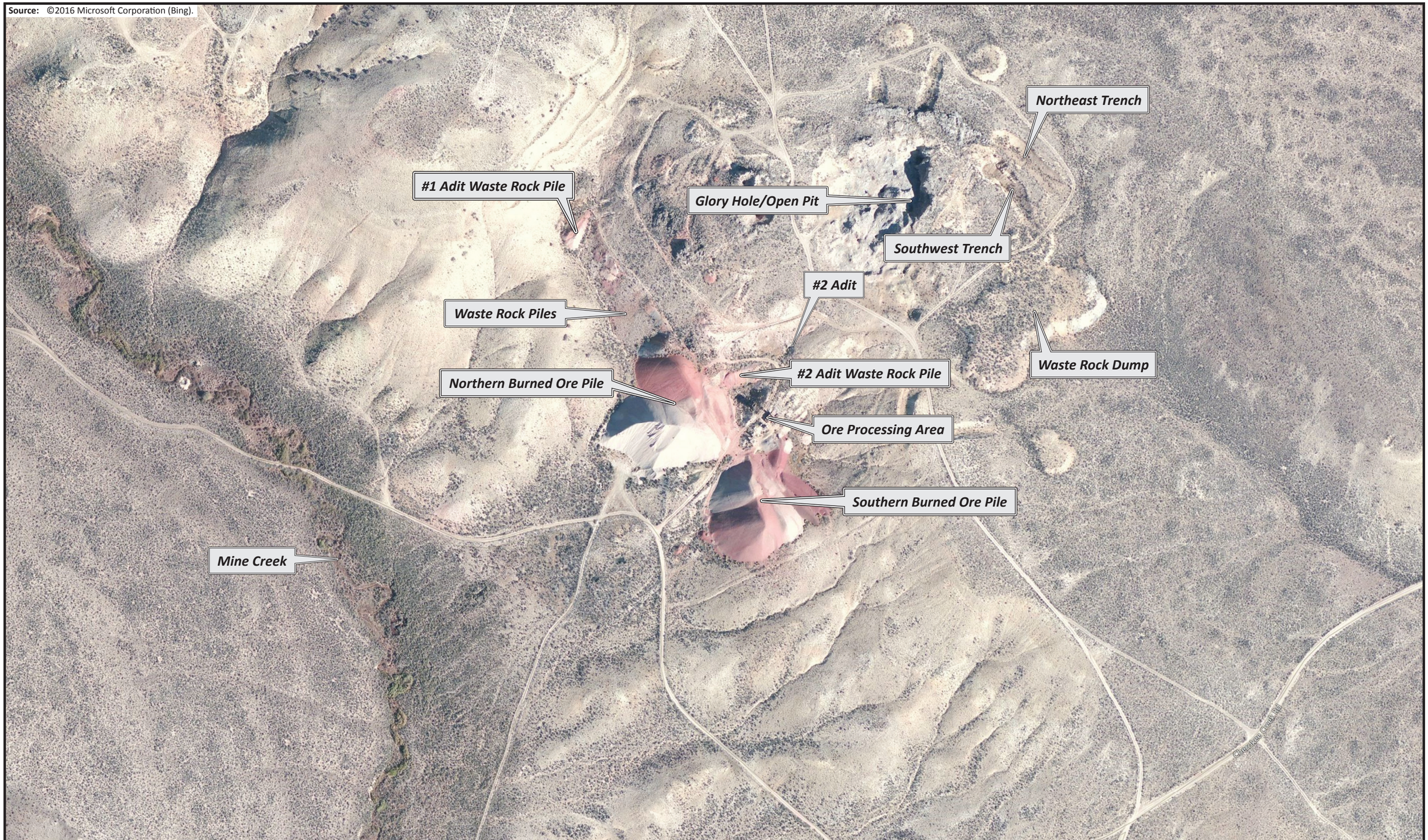
0 1.5 3
Approximate Scale in Miles

OPALITE MINE SITE
Malheur County, Oregon

Figure 1
Site Location

Date:	Drawn by:	
11/3/16	AES	10:START IV\16030008\fig 1

This page intentionally left blank.



ecology and environment, inc.
Global Environmental Specialists
Seattle, Washington

0 200 400
Approximate Scale in Feet

N

OPALITE MINE SITE
Malheur County, Oregon

Figure 2
Site Layout and Key Features

Date:	Drawn by:	
11/18/16	AES	10:START IV\16030008\fig 2

This page intentionally left blank.

Source: ©2016 Microsoft Corporation (Bing).

Key:

Ambient Air Screening Location for Mercury Vapor with Jerome J505

µg/m³ micrograms per cubic meter

Northeast Trench

Glory Hole/Open Pit

0.2 µg/m³

Southwest Trench

#1 Adit Waste Rock Pile

0.03 µg/m³

0.1 µg/m³

0.04 µg/m³

0.08 µg/m³

0.04 µg/m³

0.06 µg/m³

0.12 µg/m³

Waste Rock Piles

0.04 µg/m³

Waste Rock Dump

0.1 µg/m³

#2 Adit

0.1 µg/m³

#2 Adit Waste Rock Pile

Northern Burned Ore Pile

Ore Processing Area

Southern Burned Ore Pile

ecology and environment, inc.
Global Environmental Specialists
Seattle, Washington

0 200 400
Approximate Scale in Feet

N

OPALITE MINE SITE
Malheur County, Oregon

Figure 3
Mercury Vapor Ambient Air Monitoring Locations

Date:	Drawn by:	
11/18/16	AES	10:START IV\16030008\fig 3

This page intentionally left blank.

Source: ©2016 Microsoft Corporation (Bing).

Key:

- Test Pit Location
- Ambient Air Screening Location for Mercury Vapor with Jerome J505 – Prior to Test Pit Excavation
- µg/m³ micrograms per cubic meter

Test Pit 3

0.1 µg/m³

Test Pit 2

Test Pit 1

Concrete Slab

Concrete Rubble

Test Pit 4

Collapsed Corrugated Metal Structure(s)

0.2 µg/m³

Pieces of Broken Clay Pipe (6-inch, 12-inch, and 18-inch diameter) from Former Condenser

Wooden Structure

Test Pit 5

1.1 µg/m³

Concrete Slab with Pedestals

Small Pile of Gray Silty Material (soot?)

Concrete Vat

0.0 µg/m³

0.0 µg/m³

Concrete Vat

1.2 µg/m³

2.0 µg/m³

Test Pit 6

Concrete Pedestal

0.1 µg/m³

Pile of Rusted 55-Gallon Drums, 25-Gallon Containers, and Metal Pipe

0.2 µg/m³

Closed Depression

Concrete Pedestal

1.5 µg/m³

Refuse Pile Including Clay Pipe and Black, Fine-Grained Material (soot?)

ecology and environment, inc.
Global Environmental Specialists
Seattle, Washington

OPALITE MINE SITE
Malheur County, Oregon

0 30 60
Approximate Scale in Feet

Figure 4
Mercury Ambient Vapor Air Monitoring Locations – Ore Processing Area

Date:	Drawn by:	
11/9/16	AES	10:START IV\16030008\fig 4

This page intentionally left blank.

Source: ©2016 Microsoft Corporation (Bing).

N

Key:

- Test Pit/Soil Sample Location
- Soil Sample Location

Test Pit 3
Location ID
TP03SS0.5
TP03SB1.5

Test Pit 1

Test Pit 2
Location ID
TP02SB1.5
TP02SB2.5

Test Pit 5
Location ID
TP05SB02
TP05SB04
TP05SB05
TP05SB07
TP05SB08
TP05SB20

Test Pit 4
Location ID
TP04SS0.5
TP04SB2.5
TP04SB3.5

Northern Burned Ore Pile

OP01SS0.5
Location ID
OP01SS0.5

Ore Processing Area

Test Pit 6
Location ID
TP06SB03
TP06SB04
TP06SB06
TP06SB07
TP06SB08
TP06SB20

Test Pit 8
Location ID
TP08SB05

Test Pit 7
Location ID
TP07SB05

Southern Burned Ore Pile

ecology and environment, inc.
Global Environmental Specialists
Seattle, Washington

OPALITE MINE SITE
Malheur County, Oregon

0 25 50
Approximate Scale in Feet

Figure 5
Test Pit Locations

Date:	Drawn by:	
11/18/16	AES	10:START IV\16030008\fig 5

This page intentionally left blank.

Source: ©2016 Microsoft Corporation (Bing).

Key:

- START XRF Sample Location
- Hg Mercury
- As Arsenic
- Sb Antimony

Note: Sample results are in parts per million (ppm).

EPA - 21	
Hg	30
As	76
Sb	23

EPA - 20	
Hg	119
As	192
Sb	119

EPA - 13	
Hg	37
As	26
Sb	22

EPA - 12	
Hg	123
As	88
Sb	41

EPA - 11	
Hg	233
As	212
Sb	78

EPA - 34	
Hg	362
As	191
Sb	170

EPA - 33	
Hg	3,418
As	726
Sb	273

EPA - 31	
Hg	36
As	71
Sb	32

EPA - 32	
Hg	480
As	231
Sb	141

EPA - 15	
Hg	1,862
As	73
Sb	42

EPA - 37	
Hg	1,114
As	265
Sb	277

EPA - 19	
Hg	758
As	255
Sb	237

EPA - 35	
Hg	782
As	161
Sb	163

EPA - 36	
Hg	207
As	55
Sb	70

EPA - 38	
Hg	479
As	85
Sb	127

EPA - 39	
Hg	316
As	207
Sb	345

EPA - 54	
Hg	438
As	1,511
Sb	1,087

EPA - 41	
Hg	369
As	85
Sb	67

EPA - 45	
Hg	916
As	4,667
Sb	363

EPA - 42	
Hg	129
As	68
Sb	42

EPA - 53	
Hg	1,290
As	3,227
Sb	592

EPA - 55	
Hg	353
As	223
Sb	230

EPA - 44	
Hg	355
As	3,059
Sb	647

EPA - 46	
Hg	83
As	999
Sb	1,199

EPA - 43	
Hg	474
As	117
Sb	105

EPA - 47	
Hg	96
As	1,570
Sb	1,350

EPA - 48	
Hg	139
As	137
Sb	210

EPA - 52	
Hg	43
As	983
Sb	1,120

EPA - 49	
Hg	30
As	1,110
Sb	2,123

EPA - 51	
Hg	25
As	1,159
Sb	1,748

ecology and environment, inc.
Global Environmental Specialists
Seattle, Washington

OPALITE MINE SITE
Malheur County, Oregon

0 25 50
Approximate Scale in Feet

Figure 6
In Situ XRF Screening Locations

Date:	Drawn by:	
11/9/16	AES	10:START IV\16030008\fig 6

This page intentionally left blank.

Source: ©2016 Microsoft Corporation (Bing).

Key:

- Oregon Department of Environmental QualityXRF Sample Location
- Hg Mercury
- As Arsenic
- Sb Antimony

Note: Sample results are in parts per million (ppm).

Glory Hole/Open Pit

Northeast Trench

#1 Adit Waste Rock Pile

ODEQ - 69
Hg 381
As 12
Sb <LOD

ODEQ - 68
Hg 1,263
As 160
Sb 187

Southwest Trench

#2 Adit

Waste Rock Piles

Waste Rock Dump

#2 Adit Waste Rock Pile

Northern Burned Ore Pile

Mine Creek

ODEQ - 17
Hg <LOD
As 37
Sb <LOD

ODEQ - 26
Hg 37
As 55
Sb <LOD

Ore Processing Area

ODEQ - 18
Hg 32
As 39
Sb <LOD

ODEQ - 25
Hg 94
As 24
Sb <LOD

Southern Burned Ore Pile

ODEQ - 21
Hg <LOD
As 33
Sb <LOD

ODEQ - 27
Hg 84
As 113
Sb <LOD

ODEQ - 30
Hg 68
As 555
Sb 1,321

ODEQ - 22
Hg <LOD
As <LOD
Sb <LOD

ODEQ - 19
Hg 27
As 49
Sb <LOD

ODEQ - 24
Hg 27
As 44
Sb <LOD

ODEQ - 31
Hg 62
As 21
Sb <LOD

ODEQ - 29
Hg 49
As 83
Sb <LOD

ODEQ - 20
Hg 21
As 39
Sb <LOD

ODEQ - 28
Hg 58
As 179
Sb <LOD

ODEQ - 23
Hg <LOD
As <LOD
Sb <LOD

ODEQ - 32
Hg <LOD
As 31
Sb <LOD

Chronicle Creek Rd

ecology and environment, inc.
Global Environmental Specialists
Seattle, Washington

0 200 400
Approximate Scale in Feet

N

OPALITE MINE SITE
Malheur County, Oregon

Figure 7
In Situ XRF Screening of Overland Drainage Pathways

Date:	Drawn by:	
11/9/16	AES	10:START IV\16030008\fig 7

This page intentionally left blank.

Table 1

Historical Soil/Mine Waste Materials Results Summary
Opalite Mine Removal Assessment
Malheur County, Oregon

Field Event	Citation	Field Sampling Date	Sample # / Location ID	Sample ID	Depth (ft bgs)	Sample Location - From Report	Sample Location - Standardized	Laboratory Total Hg (mg/kg)	XRF Hg (ppm)	Lumex Hg (ppm)		Laboratory Total As (mg/kg)	XRF As (ppm)		Laboratory Total Sb (mg/kg)		XRF Sb (ppm)
							RSL - Residential[1]	**11**	**11**	**11**		**0.68**	**0.68**		**31**		**31**
							RSL - Industrial[1]	**46**	**46**	**46**		**3**	**3**		**470**		**470**
							RML - Residential[1]	**33**	**33**	**33**		**68**	**68**		**94**		**94**
							RML - Industrial[1]	**140**	**140**	**140**		**300**	**300**		**1400**		**1400**
2003 EPA SI	Weston 2003	June 2002	BK001	OM-SS-BK001-0000	0.0 - 0.25	Background	Background	0.88				5			0.46	R	
2001 ODEQ PA	ODEQ 2001	June 2000	--	--		#1 Adit	Adit/Tunnel #1 Soil Pile	478									
2003 EPA SI	Weston 2003	June 2002	MS010	OM-SS-MS010-0001	0.0 - 0.25	#1 Adit Soil Pile	Adit/Tunnel #1 Soil Pile	38.4				286			5.8	BJL	
2005 ODEQ SI	E & E 2005	December 2003	WR04	WR04SS01	0 - 0.5	Waste Rock Piles (Tunnels 1, 2)	Adit/Tunnel #1 Waste Rock Pile			61.5							
2005 ODEQ SI	E & E 2005	December 2003	WR05	WR05SS01	0 - 0.5	Waste Rock Piles (Tunnels 1, 2)	Adit/Tunnel #1 Waste Rock Pile	92.4		72.4		36.9			6.46	J	
2005 ODEQ SI	E & E 2005	December 2003	WR06	WR06SS01	0 - 0.5	Waste Rock Piles (Tunnels 1, 2)	Adit/Tunnel #1 Waste Rock Pile			49.5							
2005 ODEQ SI	E & E 2005	December 2003	WR07	WR07SS01	0 - 0.5	Waste Rock Piles (Tunnels 1, 2)	Adit/Tunnel #1 Waste Rock Pile			35							
2005 ODEQ SI	E & E 2005	June 2004	WR12	WR12SS01	2 - 3	Waste Rock Piles (Tunnels 1, 2)	Adit/Tunnel #1 Waste Rock Pile	30.7	49.23	29.68		91.7	314.1		1.39	J	71.83
2005 ODEQ SI	E & E 2005	December 2003	WR01	WR01SS01	0 - 0.5	Waste Rock Piles (Tunnels 1, 2)	Adit/Tunnel #2 Waste Rock Pile	205		150		326			14.9	J	
2005 ODEQ SI	E & E 2005	December 2003	WR03	WR03SS01	0 - 0.5	Waste Rock Piles (Tunnels 1, 2)	Adit/Tunnel #2 Waste Rock Pile			27.8							
2005 ODEQ SI	E & E 2005	June 2004	WR11	WR11SS01	2 - 3	Waste Rock Piles (Tunnels 1, 2)	Adit/Tunnel #2 Waste Rock Pile	94.3	198.9	32.6		383	890		44.3	J	77.22
2001 ODEQ PA	ODEQ 2001	June 2000	--	--		Open Pit	Glory Hole / Open Pit	51									
2003 EPA SI	Weston 2003	June 2002	MS009	OM-SS-MS009-0001	0.0 - 0.25	Open Mine Pit	Glory Hole / Open Pit	792				289			71.6	JL	
2005 ODEQ SI	E & E 2005	December 2003	GH01	GH01SM01	0 - 0.5	Glory Hole	Glory Hole / Open Pit	179				2.6			1.33	J	
2005 ODEQ SI	E & E 2005	December 2003	GH02	GH02SM01	0 - 0.5	Glory Hole	Glory Hole / Open Pit	593				7.2			1.04	J	
2005 ODEQ SI	E & E 2005	June 2004	RD01	RD01SS01	0 - 0.5	Gravel Road	Gravel Road		28.35	1.2			12.95				80.48
2005 ODEQ SI	E & E 2005	June 2004	RD02	RD02SS02	0 - 0.5	Gravel Road	Gravel Road		14.62	2.14			9.77				82.68
2005 ODEQ SI	E & E 2005	June 2004	RD03	RD03SS03	0 - 0.5	Gravel Road	Gravel Road		14.76	0.5			15.03				79.9
2005 ODEQ SI	E & E 2005	June 2004	RD04	RD04SS04	0 - 0.5	Gravel Road	Gravel Road		41.73	3.92			11.5				76.02
2005 ODEQ SI	E & E 2005	June 2004	RD05	RD05SS05	0 - 0.5	Gravel Road	Gravel Road		20.6	5.75			8.46				90.02
2005 ODEQ SI	E & E 2005	June 2004	RD06	RD06SS06	0 - 0.5	Gravel Road	Gravel Road		81.45	11.7			11.19				79.23
2005 ODEQ SI	E & E 2005	June 2004	RD07	RD07SS07	0 - 0.5	Gravel Road	Gravel Road		31.33	3.02			19.14				84.46
2005 ODEQ SI	E & E 2005	June 2004	RD08	RD08SS08	0 - 0.5	Gravel Road	Gravel Road		65.35	11			36.56				77.8
2005 ODEQ SI	E & E 2005	June 2004	RD09	RD09SS09	0 - 0.5	Gravel Road	Gravel Road		39.27	4.82			36.69				79.24
2005 ODEQ SI	E & E 2005	June 2004	RD10	RD10SS10	0 - 0.5	Gravel Road	Gravel Road		68.71	3.12			10.65				78.65
2005 ODEQ SI	E & E 2005	June 2004	RD11	RD11SS01	0 - 0.5	Gravel Road	Gravel Road		19.48	5.68			20.29				76.3
2005 ODEQ SI	E & E 2005	June 2004	RD12	RD12SS01	0 - 0.5	Gravel Road	Gravel Road		19.06	1.43			10.51				76.04
2005 ODEQ SI	E & E 2005	June 2004	RD13	RD13SS01	0 - 0.5	Gravel Road	Gravel Road		73.13	13.3			28.72				73.77
2005 ODEQ SI	E & E 2005	June 2004	RD14	RD14SS01	0 - 0.5	Gravel Road	Gravel Road		23.94	1.97			50.83				82.7
2005 ODEQ SI	E & E 2005	June 2004	RD15	RD15SS01	0 - 0.5	Gravel Road	Gravel Road		8.37	0.0029			11.92				83.69
2005 ODEQ SI	E & E 2005	June 2004	RD16	RD16SS01	0 - 0.5	Gravel Road	Gravel Road		22.66	2.22			27.47				83.54
2005 ODEQ SI	E & E 2005	June 2004	RD17	RD17SS01	0 - 0.5	Gravel Road	Gravel Road		15.15	1.68			41.53				96.63
2005 ODEQ SI	E & E 2005	June 2004	RD18	RD18SS01	0 - 0.5	Gravel Road	Gravel Road		17.73	0.651			24.12				84.85
2005 ODEQ SI	E & E 2005	June 2004	RD19	RD19SS01	0 - 0.5	Gravel Road	Gravel Road		9.84	1.49			29.7				85.22
2005 ODEQ SI	E & E 2005	June 2004	RD20	RD20SS02	0 - 0.5	Gravel Road	Gravel Road		8.77	0.308			13.71				82.97
2001 ODEQ PA	ODEQ 2001	June 2000	--	--		Burned Ore	Northern Burned Ore Pile	21.8									
2003 EPA SI	Weston 2003	June 2002	MS001	OM-SS-MS001-0000	0.0 - 0.25	Northern Burned Ore Pile	Northern Burned Ore Pile	21				31.3			2.1	BJL	
2003 EPA SI	Weston 2003	June 2002	MS002	OM-SS-MS002-0000	0.0 - 0.33	Northern Burned Ore Pile	Northern Burned Ore Pile	70.2				1060			205	JL	
2005 ODEQ SI	E & E 2005	December 2003	NP01	NP01SS01	0 - 0.5	Northern Burned Ore Pile	Northern Burned Ore Pile	60.7		48		679			471	J	
2005 ODEQ SI	E & E 2005	December 2003	NP02	NP02SS01	0 - 0.5	Northern Burned Ore Pile	Northern Burned Ore Pile			26.9							
2005 ODEQ SI	E & E 2005	December 2003	NP03	NP03SS01	0 - 0.5	Northern Burned Ore Pile	Northern Burned Ore Pile	33.7		82		32.3			2.76	J	
2005 ODEQ SI	E & E 2005	December 2003	NP04	NP04SS01	0 - 0.5	Northern Burned Ore Pile	Northern Burned Ore Pile	66.2		57		503			262	J	
2005 ODEQ SI	E & E 2005	December 2003	NP06	NP06SS01	0 - 0.5	Northern Burned Ore Pile	Northern Burned Ore Pile			33.9							
2005 ODEQ SI	E & E 2005	June 2004	NP07	NP07SB01	2 - 3	Northern Burned Ore Pile	Northern Burned Ore Pile	85.5	130	50		321	431		212	J	1161

Table 1

Historical Soil/Mine Waste Materials Results Summary
Opalite Mine Removal Assessment
Malheur County, Oregon

Field Event	Citation	Field Sampling Date	Sample # / Location ID	Sample ID	Depth (ft bgs)	Sample Location - From Report	Sample Location - Standardized	Laboratory Total Hg (mg/kg)	XRF Hg (ppm)	Lumex Hg (ppm)		Laboratory Total As (mg/kg)	XRF As (ppm)		Laboratory Total Sb (mg/kg)		XRF Sb (ppm)
							RSL - Residential[1]	**11**	**11**	**11**		**0.68**	**0.68**		**31**		**31**
							RSL - Industrial[1]	**46**	**46**	**46**		**3**	**3**		**470**		**470**
							RML - Residential[1]	**33**	**33**	**33**		**68**	**68**		**94**		**94**
							RML - Industrial[1]	**140**	**140**	**140**		**300**	**300**		**1400**		**1400**
2003 EPA SI	Weston 2003	June 2002	MS005	OM-SS-MS005-0000	0.0 - 0.25	Former Ore Processing Facility	Ore Processing Area	97.3				52.8			5.3	BJL	
2003 EPA SI	Weston 2003	June 2002	MS006	OM-SS-MS006-0000	0.0 - 0.25	Former Ore Processing Facility	Ore Processing Area	65.3				39.5			2	UJL	
2003 EPA SI	Weston 2003	June 2002	MS007	OM-SS-MS007-0000	0.0 - 0.25	Former Ore Processing Facility	Ore Processing Area	38.5				17.6			1.1	UJL	
2003 EPA SI	Weston 2003	June 2002	MS008	OM-SS-MS008-0000	0.0 - 0.25	Former Ore Processing Facility	Ore Processing Area	498				334			6.5	BJL	
2005 ODEQ SI	E & E 2005	December 2003	OP02	OP02SS01	0 - 0.5	Ore Processing Area	Ore Processing Area			45							
2005 ODEQ SI	E & E 2005	December 2003	OP03	OP03SS01	0 - 0.5	Ore Processing Area	Ore Processing Area			34							
2005 ODEQ SI	E & E 2005	December 2003	OP04	OP04SS01	0 - 0.5	Ore Processing Area	Ore Processing Area			76							
2005 ODEQ SI	E & E 2005	December 2003	OP06	OP06SS01	0 - 0.5	Ore Processing Area	Ore Processing Area	145		78		111			14.5	J	
2005 ODEQ SI	E & E 2005	December 2003	OP07	OP07SS01	0 - 0.5	Ore Processing Area	Ore Processing Area			66							
2005 ODEQ SI	E & E 2005	December 2003	OP13	OP13SS01	0 - 0.5	Ore Processing Area	Ore Processing Area			30.4							
2005 ODEQ SI	E & E 2005	December 2003	OP14	OP14SS01	0 - 0.5	Ore Processing Area	Ore Processing Area			57.1							
2005 ODEQ SI	E & E 2005	December 2003	OP15	OP15SS01	0 - 0.5	Ore Processing Area	Ore Processing Area			8.84							
2005 ODEQ SI	E & E 2005	December 2003	OP18	OP18SS01	0 - 0.5	Ore Processing Area	Ore Processing Area	168		119		101			16.1	J	
2005 ODEQ SI	E & E 2005	December 2003	OP19	OP19SS01	0 - 0.5	Ore Processing Area	Ore Processing Area			29.9							
2005 ODEQ SI	E & E 2005	December 2003	OP20	OP20SS02	0 - 0.5	Ore Processing Area	Ore Processing Area			8.9							
2005 ODEQ SI	E & E 2005	December 2003	OP21	OP21SS02	0 - 0.5	Ore Processing Area	Ore Processing Area			14							
2005 ODEQ SI	E & E 2005	December 2003	OP22	OP22SS02	0 - 0.5	Ore Processing Area	Ore Processing Area			39							
2005 ODEQ SI	E & E 2005	December 2003	OP23	OP23SS02	0 - 0.5	Ore Processing Area	Ore Processing Area			46							
2005 ODEQ SI	E & E 2005	December 2003	OP24	OP24SS02	0 - 0.5	Ore Processing Area	Ore Processing Area			40							
2005 ODEQ SI	E & E 2005	December 2003	OP25	OP25SS02	0 - 0.5	Ore Processing Area	Ore Processing Area			52							
2005 ODEQ SI	E & E 2005	December 2003	OP26	OP26SS02	0 - 0.5	Ore Processing Area	Ore Processing Area			63							
2005 ODEQ SI	E & E 2005	December 2003	OP27	OP27SS02	0 - 0.5	Ore Processing Area	Ore Processing Area			50							
2005 ODEQ SI	E & E 2005	December 2003	OP28	OP28SS02	0 - 0.5	Ore Processing Area	Ore Processing Area			49							
2005 ODEQ SI	E & E 2005	December 2003	OP29	OP29SS02	0 - 0.5	Ore Processing Area	Ore Processing Area			51							
2005 ODEQ SI	E & E 2005	December 2003	OP30	OP30SS03	0 - 0.5	Ore Processing Area	Ore Processing Area			35							
2005 ODEQ SI	E & E 2005	December 2003	OP31	OP31SS03	0 - 0.5	Ore Processing Area	Ore Processing Area			20.6							
2005 ODEQ SI	E & E 2005	December 2003	OP32	OP32SS03	0 - 0.5	Ore Processing Area	Ore Processing Area			13.1							
2005 ODEQ SI	E & E 2005	December 2003	OP33	OP33SS03	0 - 0.5	Ore Processing Area	Ore Processing Area	195		85		172			9.98	J	
2005 ODEQ SI	E & E 2005	December 2003	OP34	OP34SS03	0 - 0.5	Ore Processing Area	Ore Processing Area			54							
2005 ODEQ SI	E & E 2005	December 2003	OP35	OP35SS03	0 - 0.5	Ore Processing Area	Ore Processing Area	253		100		166			14.3	J	
2005 ODEQ SI	E & E 2005	December 2003	OP36	OP36SS03	0 - 0.5	Ore Processing Area	Ore Processing Area			40							
2005 ODEQ SI	E & E 2005	December 2003	OP37	OP37SS03	0 - 0.5	Ore Processing Area	Ore Processing Area			60.8							
2005 ODEQ SI	E & E 2005	June 2004	OP38	OP38SS03	2 - 3	Ore Processing Area	Ore Processing Area	35.1	71.05	75.37		128	186.5		1.92	J	73.85
2005 ODEQ SI	E & E 2005	June 2004	OP39	OP39SS03	2 - 3	Ore Processing Area	Ore Processing Area	29	47.59	7.602		61.8	51.74		5	J	77.56
2003 EPA SI	Weston 2003	June 2002	MS003	OM-SS-MS003-0000	0.0 - 0.33	Southern Burned Ore Pile	Southern Burned Ore Pile	14.8				758			226	JL	
2003 EPA SI	Weston 2003	June 2002	MS004	OM-SS-MS004-0000	0.0 - 0.33	Southern Burned Ore Pile	Southern Burned Ore Pile	23.4				656			122	JL	
2005 ODEQ SI	E & E 2005	December 2003	SP01	SP01SS01	0 - 0.5	Southern Burned Ore Pile	Southern Burned Ore Pile	16.5		11.7		12.6			27.2	J	
2005 ODEQ SI	E & E 2005	December 2003	SP02	SP02SS01	0 - 0.5	Southern Burned Ore Pile	Southern Burned Ore Pile			2.2							
2005 ODEQ SI	E & E 2005	December 2003	SP03	SP03SS01	0 - 0.5	Southern Burned Ore Pile	Southern Burned Ore Pile	20.1		10		1060			349	J	
2005 ODEQ SI	E & E 2005	December 2003	SP04	SP04SS01	0 - 0.5	Southern Burned Ore Pile	Southern Burned Ore Pile			7.6							
2005 ODEQ SI	E & E 2005	December 2003	SP05	SP05SS01	0 - 0.5	Southern Burned Ore Pile	Southern Burned Ore Pile	11.7		14.6		163			28.8	J	
2005 ODEQ SI	E & E 2005	December 2003	SP06	SP06SS01	0 - 0.5	Southern Burned Ore Pile	Southern Burned Ore Pile			8.18							
2005 ODEQ SI	E & E 2005	June 2004	SP07	SP07SB01	2 - 3	Southern Burned Ore Pile	Southern Burned Ore Pile	44.8	79	14		1700	1470		225	J	1578
2005 ODEQ SI	E & E 2005	December 2003	DP01	DP01SS01	0 - 0.5	Waste Rock Dump (east of GH)	Waste Rock Dump (east of GH)	33.5		30.4		155			7.33	J	

Table 1

Historical Soil/Mine Waste Materials Results Summary
Opalite Mine Removal Assessment
Malheur County, Oregon

Field Event	Citation	Field Sampling Date	Sample # / Location ID	Sample ID	Depth (ft bgs)	Sample Location - From Report	Sample Location - Standardized	Laboratory Total Hg (mg/kg)	XRF Hg (ppm)	Lumex Hg (ppm)	Laboratory Total As (mg/kg)	XRF As (ppm)	Laboratory Total Sb (mg/kg)		XRF Sb (ppm)
							RSL - Residential[1]	**11**	**11**	**11**	**0.68**	**0.68**	**31**		**31**
							RSL - Industrial[1]	**46**	**46**	**46**	**3**	**3**	**470**		**470**
							RML - Residential[1]	**33**	**33**	**33**	**68**	**68**	**94**		**94**
							RML - Industrial[1]	**140**	**140**	**140**	**300**	**300**	**1400**		**1400**
2005 ODEQ SI	E & E 2005	December 2003	DP02	DP02SS01	0 - 0.5	Waste Rock Dump (east of GH)	Waste Rock Dump (east of GH)	52.7		37	205		2.23	J	
2005 ODEQ SI	E & E 2005	December 2003	DP03	DP03SS01	0 - 0.5	Waste Rock Dump (east of GH)	Waste Rock Dump (east of GH)	286		76	23.3		3.17	J	
2005 ODEQ SI	E & E 2005	December 2003	DP04	DP04SS01	0 - 0.5	Waste Rock Dump (east of GH)	Waste Rock Dump (east of GH)	13.7		12.1	24.2		1.81	J	
2005 ODEQ SI	E & E 2005	December 2003	WR09	WR09SS01	0 - 0.5	Waste Rock Piles (Tunnels 1, 2)	Waste Rock Piles			25.9					
2005 ODEQ SI	E & E 2005	December 2003	WR10	WR10SS01	0 - 0.5	Waste Rock Piles (Tunnels 1, 2)	Waste Rock Piles			38.2					
							Average	**130.4**	**46.2**	**33.4**	**285.6**	**145.2**	**67.8**		**179.8**
							Maximum	**792.0**	**198.9**	**150.0**	**1700.0**	**1470.0**	**471.0**		**1578.0**
							Count	*38*	*26*	*77*	*35*	*26*	*35*		*26*
							# Exceed RSL-Residential	*37*	*23*	*52*	*35*	*26*	*10*		*26*
							# Exceed RSL-Industrial	*21*	*10*	*24*	*34*	*26*	*1*		*2*
							# Exceed RML-Residential	*27*	*12*	*35*	*22*	*5*	*8*		*3*
							# Exceed RML-Industrial	*11*	*1*	*1*	*11*	*4*	*0*		*1*

[1] **RSL and RML values are for Mercury (elemental); Arsenic, Inorganic; and Antimony (metallic).**

Key:

J The analyte was positively identified. The associated numerical result is an estimate.
R Quality Control indicates that data are unusable (compound may or may not be present)
U The analyte was not detected at or above the reported result
B The result is below the Contract Required Detection Limit (CRDL)
L Low bias

This page intentionally left blank.

Table 2

Summary of Historical Soil/Mine Waste Material Data by Sub-Area
Opalite Mine Removal Assessment
Malheur County, Oregon

Sample Location / Site Area	Screening Level	Mercury			Arsenic		Antimony	
		Laboratory Total Hg (mg/kg)	XRF Hg (ppm)	Lumex Hg (ppm)	Laboratory Total As (mg/kg)	XRF As (ppm)	Laboratory Total Sb (mg/kg)	XRF Sb (ppm)
	RSL - Residential[1]	**11**	**11**	**11**	**0.68**	**0.68**	**31**	**31**
	RSL - Industrial[1]	**46**	**46**	**46**	**3**	**3**	**470**	**470**
	RML - Residential[1]	**33**	**33**	**33**	**68**	**68**	**94**	**94**
	RML - Industrial[1]	**140**	**140**	**140**	**300**	**300**	**1,400**	**1,400**
Background	**Average Conc.**	**0.9**	**NA**	**NA**	**5.0**	**NA**	**0.5**	**NA**
	Maximum Conc.	**0.88**	**NA**	**NA**	**5.0**	**NA**	**0.5**	**NA**
	Count	1	0	0	1	0	1	0
	# Exceed RSL - Residential	0	0	0	1	0	0	0
	# Exceed RSL - Industrial	0	0	0	1	0	0	0
	# Exceed RML - Residential	0	0	0	0	0	0	0
	# Exceed RML - Industrial	0	0	0	0	0	0	0
Northern Burned Ore Pile	**Average Conc.**	**51.3**	**130.0**	**49.6**	**437.8**	**431.0**	**192.5**	**1,161**
	Maximum Conc.	**85.5**	**130**	**82**	**1,060**	**431**	**471**	**1,161**
	Count	7	1	6	6	1	6	1
	# Exceed RSL - Residential	7	1	6	6	1	4	1
	# Exceed RSL - Industrial	4	1	4	6	1	1	1
	# Exceed RML - Residential	5	1	5	4	1	4	1
	# Exceed RML - Industrial	0	0	0	4	1	0	0
Southern Burned Ore Pile	**Average Conc.**	**21.9**	**79.0**	**9.8**	**724.9**	**1,470**	**163.0**	**1,578**
	Maximum Conc.	**44.8**	**79**	**14.6**	**1,700**	**1,470**	**349**	**1,578**
	Count	6	1	7	6	1	6	1
	# Exceed RSL - Residential	6	1	3	6	1	4	1
	# Exceed RSL - Industrial	0	1	0	6	1	0	1
	# Exceed RML - Residential	1	1	0	5	1	4	1
	# Exceed RML - Industrial	0	0	0	4	1	0	1
Ore Processing Area	**Average Conc.**	**152.4**	**59.3**	**48.3**	**118.4**	**119.1**	**7.7**	**75.7**
	Maximum Conc.	**498**	**71.05**	**119**	**334**	**186.5**	**16.1**	**77.6**
	Count	10	2	30	10	2	10	2
	# Exceed RSL - Residential	10	2	27	10	2	0	2
	# Exceed RSL - Industrial	7	2	15	10	2	0	0
	# Exceed RML - Residential	9	2	22	6	1	0	0
	# Exceed RML - Industrial	5	0	0	1	0	0	0
# 1 Adit Waste Rock Pile	**Average Conc.**	**159.9**	**49.2**	**49.6**	**138.2**	**314.1**	**4.6**	**71.8**
	Maximum Conc.	**478**	**49.2**	**72.4**	**286**	**314.1**	**6.5**	**71.8**
	Count	4	1	5	3	1	3	1
	# Exceed RSL - Residential	4	1	5	3	1	0	1
	# Exceed RSL - Industrial	2	1	3	3	1	0	0
	# Exceed RML - Residential	3	1	4	2	1	0	0
	# Exceed RML - Industrial	1	0	0	0	1	0	0
#2 Adit Waste Rock Pile	**Average Conc.**	**149.7**	**198.9**	**70.1**	**354.5**	**890**	**29.6**	**77.2**
	Maximum Conc.	**205**	**198.9**	**150**	**383**	**890**	**44.3**	**77.2**
	Count	2	1	3	2	1	2	1
	# Exceed RSL - Residential	2	1	3	2	1	1	1
	# Exceed RSL - Industrial	2	1	1	2	1	0	0
	# Exceed RML - Residential	2	1	1	2	1	0	0
	# Exceed RML - Industrial	1	1	1	2	1	0	0
Waste Rock Piles	**Average Conc. (mg/kg(**	**NA**	**NA**	**32.1**	**NA**	**NA**	**NA**	**NA**
	Maximum Conc.	**NA**	**NA**	**38.2**	**NA**	**NA**	**NA**	**NA**
	Count	0	0	2	0	0	0	0
	# Exceed RSL - Residential	0	0	2	0	0	0	0
	# Exceed RSL - Industrial	0	0	0	0	0	0	0
	# Exceed RML - Residential	0	0	1	0	0	0	0
	# Exceed RML - Industrial	0	0	0	0	0	0	0
Glory Hole / Open Pit	**Average Conc.**	**403.8**	**0.0**	**0.0**	**99.6**	**0.0**	**24.7**	**NA**
	Maximum Conc.	**792**	**0**	**0**	**289**	**0**	**71.6**	**NA**
	Count	4	0	0	3	0	3	0
	# Exceed RSL - Residential	4	0	0	3	0	1	0
	# Exceed RSL - Industrial	4	0	0	2	0	0	0
	# Exceed RML - Residential	4	0	0	1	0	0	0
	# Exceed RML - Industrial	3	0	0	0	0	0	0
Waste Rock Dump (east of GH)	**Average Conc.**	**96.5**	**0.0**	**38.9**	**101.9**	**0.0**	**3.6**	**NA**
	Maximum Conc.	**286**	**0**	**76**	**205**	**0**	**7.33**	**NA**
	Count	4	0	4	4	0	4	0
	# Exceed RSL - Residential	4	0	4	4	0	0	0
	# Exceed RSL - Industrial	2	0	1	4	0	0	0
	# Exceed RML - Residential	3	0	2	2	0	0	0
	# Exceed RML - Industrial	1	0	0	0	0	0	0

Table 2

Summary of Historical Soil/Mine Waste Material Data by Sub-Area
Opalite Mine Removal Assessment
Malheur County, Oregon

Sample Location / Site Area	Screening Level	Mercury			Arsenic		Antimony	
		Laboratory Total Hg (mg/kg)	XRF Hg (ppm)	Lumex Hg (ppm)	Laboratory Total As (mg/kg)	XRF As (ppm)	Laboratory Total Sb (mg/kg)	XRF Sb (ppm)
	RSL - Residential[1]	**11**	**11**	**11**	**0.68**	**0.68**	**31**	**31**
	RSL - Industrial[1]	**46**	**46**	**46**	**3**	**3**	**470**	**470**
	RML - Residential[1]	**33**	**33**	**33**	**68**	**68**	**94**	**94**
	RML - Industrial[1]	**140**	**140**	**140**	**300**	**300**	**1,400**	**1,400**
Gravel Road	**Average Conc.**	**NA**	**31.2**	**3.8**	**NA**	**21.5**	**NA**	**81.7**
	Maximum Conc.	**NA**	**81.5**	**13.3**	**NA**	**50.8**	**NA**	**96.6**
	Count	0	20	20	0	20	0	20
	# Exceed RSL - Residential	0	17	2	0	20	0	20
	# Exceed RSL - Industrial	0	4	0	0	20	0	0
	# Exceed RML - Residential	0	6	0	0	0	0	1
	# Exceed RML - Industrial	0	0	0	0	0	0	0
Total - Site-wide	**Average Conc.**	**130.4**	**46.2**	**33.4**	**285.6**	**145.2**	**67.8**	**179.8**
	Maximum Conc.	**792**	**198.9**	**150**	**1,700**	**1,470**	**471**	**1,578**
	Count	38	26	77	35	26	35	26
	# Exceed RSL - Residential	37	23	52	35	26	10	26
	# Exceed RSL - Industrial	21	10	24	34	26	1	2
	# Exceed RML - Residential	27	12	35	22	5	8	3
	# Exceed RML - Industrial	11	1	1	11	4	0	1

[1] **RSL and RML values are for Mercury (elemental); Arsenic, Inorganic; and Antimony (metallic).**

Key:
# = number
As = arsenic
Conc. = concentration
EPA = United States Environmental Protection Agency
Hg = mercury
Max = maximum
mg/kg = milligrams per kilogram
NA = not analyzed
OR = Oregon
RBC = risk-based concentration
RML = Removal Management Level
RSL = Regional Screening Level
SL = screening level

Table 3

Historical Sediment Results
Opalite Mine Removal Assessment
Malheur County, Oregon

Field Event	Citation	Field Sampling Date	Sample ID	Creek / Channel Name	Location Description	Location Relative to Opalite Mine	Total Hg (mg/kg)	Qual.	Hg Lumex (mg/kg)	Total As (mg/kg)	Qual.	Total Sb (mg/kg)	Qual.
						Consensus-Based TEC (McDonald et. al. 2000)	**0.18**		**0.18**	**9.79**		--	
						SQS/SL1 (Avocet 2011)	**0.66**		**0.66**	**13**		**0.3**	
						CSL/SL2 (Avocet 2011)	**0.8**		**0.8**	**120**		**12**	
2003 EPA SI	Weston 2003	June 2002	ST008	Mine Creek	Mine Creek Background	Upstream/Background	0.16	UJK		3.5	BJK	0.81	R
2003 EPA SI	Weston 2003	June 2002	ST003	McDermitt Creek	McDermitt Creek Background	Upstream/Background	0.16	U		6.9		0.55	R
2005 ODEQ SI	E & E 2005	December 2003	MC02	Mine Creek	Upstream of site	Upstream	NA		0.15	NA			
2005 ODEQ SI	E & E 2005	June 2004	CT01	Cottonwood Creek	Upstream of Mine Creek	Upstream	1.85						
2005 ODEQ SI	E & E 2005	June 2004	MC01	Mine Creek	Upstream	Upstream	0.03			2.4			
2005 ODEQ SI	E & E 2005	June 2004	MT01	McDermitt Creek	Upstream of Hot Creek	Upstream	0.02						
2005 ODEQ SI	E & E 2005	June 2004	OPCC02	Cowboy Creek	Upstream	Upstream	NA			NA			
2005 ODEQ SI	E & E 2005	June 2004	OPMW01	Mine Creek	Upstream	Upstream	0.06			2.5			
2005 ODEQ SI	E & E 2005	December 2003	IC01	Indian Creek	Upstream of McDermitt Creek	--			14.7				
2003 EPA SI	Weston 2003	June 2002	ST006	Mine Creek	PPE -- targeted at suspected overland flow drainage pathways from site sources	Downstream	0.71			6.9			
2003 EPA SI	Weston 2003	June 2002	ST007	Mine Creek	PPE -- targeted at suspected overland flow drainage pathways from site sources	Downstream	4.3			29.8			
2003 EPA SI	Weston 2003	June 2002	ST004	Mine Creek	Approx. 1/2 mile downstream from site.	Downstream	0.62			5.8			
2003 EPA SI	Weston 2003	June 2002	ST005	Mine Creek	Approx. 1/2 mile downstream from site.	Downstream	0.72			6.2			
2001 ODEQ PA	ODEQ 2001	June 2000	--	Mine Creek	Approx. 3/4 mile downstream from site.	Downstream	110			NA			
2003 EPA SI	Weston 2003	June 2002	ST001	McDermitt Creek	Downstream of confluence with Mine Creek (Approx. 3 miles from site)	Downstream	0.12	UJ		6.7			
2003 EPA SI	Weston 2003	June 2002	ST002	McDermitt Creek	Downstream of confluence with Mine Creek (Approx. 3 miles from site)	Downstream	0.1	UJ		8.5			
2005 ODEQ SI	E & E 2005	December 2003	CC01	Cowboy Creek	Downstream of site	Downstream	8.12		28	34.7		8.45	J
2005 ODEQ SI	E & E 2005	December 2003	HC01	Hot Creek	Downstream of site	Downstream	NA		1.69	NA			
2005 ODEQ SI	E & E 2005	December 2003	MC01	Mine Creek	Downstream of site	Downstream	NA		4.38	NA			
2005 ODEQ SI	E & E 2005	December 2003	MT01	McDermitt Creek	Downstream of site	Downstream	NA		1.87	NA			
2005 ODEQ SI	E & E 2005	June 2004	HC01	Hot Creek	Downstream	Downstream	1.17						
2005 ODEQ SI	E & E 2005	June 2004	MC02	Mine Creek	Downstream	Downstream	0.97						
2005 ODEQ SI	E & E 2005	June 2004	MT02	McDermitt Creek	Downstream of Hot Creek	Downstream	0.06						
2005 ODEQ SI	E & E 2005	June 2004	OPCC01	Cowboy Creek	Downstream	Downstream	0.08			3.4			

Key:

CSL/SL2 = Cleanup Screening Level / Screening Level 2
mg/kg = milligrams per kilogram
NA = Not Analyzed
PPE = probable point of entry
SQS/SL1 = Sediment Quality Standard / Screening Level 1
TEC = Threshold Effect Concentration
Qual. = Qualifier
Highlighted value exceeds screening level.

DEFINE QUALIFIERS

Table 4

Summary of Samples Submitted to a Fixed Laboratory
Opalite Mine Removal Assessment
Malheur County, Oregon

EPA Sample ID	Location ID	Sample Date	Matrix	Location Description	Sample Type	Total Hg, As, Sb	Hg SSE
16081001	TP02SB1.5	8/9/2016	Soil/Tailings	Test Pit- Ore Processing Area	Sample	X	
16081002	TP02SB2.5	8/9/2016	Soil/Tailings	Test Pit- Ore Processing Area	Sample	X	
16081003	TP03SS0.5	8/9/2016	Soil/Tailings	Test Pit- Ore Processing Area	Sample	X	
16081004	TP03SB1.5	8/9/2016	Soil/Tailings	Test Pit- Ore Processing Area	Sample	X	
16081005	TP04SS0.5	8/9/2016	Soil/Tailings	Test Pit- Ore Processing Area	Sample	X	
16081006	TP04SB2.5	8/9/2016	Soil/Tailings	Test Pit- Ore Processing Area	Sample	X	
16081007	TP04SB3.5	8/9/2016	Soil/Tailings	Test Pit- Ore Processing Area	Sample	X	
16081008	TP05SB02	8/9/2016	Soil/Tailings	Test Pit- Ore Processing Area	Sample	X	
16081022	TP05SB20	8/9/2016	Soil/Tailings	Duplicate of TP05SB02	Field Duplicate	X	
16081009	TP05SB04	8/9/2016	Soil/Tailings	Test Pit- Ore Processing Area	Sample	X	
16081010	TP05SB05	8/9/2016	Soil/Tailings	Test Pit- Ore Processing Area	Sample	X	
16081011	TP05SB07	8/9/2016	Soil/Tailings	Test Pit- Ore Processing Area	Sample	X	
16081012	TP05SB08	8/9/2016	Soil/Tailings	Test Pit- Ore Processing Area	Sample	X	
16081013	TP06SB03	8/9/2016	Soil/Tailings	Test Pit- Ore Processing Area	Sample	X	
16081021	TP06SB20	8/9/2016	Soil/Tailings	Duplicate of TP06SB03	Field Duplicate	X	
16081014	TP06SB04	8/9/2016	Soil/Tailings	Test Pit- Ore Processing Area	Sample	X	
16081015	TP06SB06	8/9/2016	Soil/Tailings	Test Pit- Ore Processing Area	Sample	X	X
16081016	TP06SB07	8/9/2016	Soil/Tailings	Test Pit- Ore Processing Area	Sample	X	
16081017	TP06SB08	8/9/2016	Soil/Tailings	Test Pit- Ore Processing Area	Sample	X	
16081018	TP07SB05	8/9/2016	Soil/Tailings	Test Pit- Southern Burned Ore Pile	Sample	X	X
16081019	TP08SB05	8/9/2016	Soil/Tailings	Test Pit- Northern Burned Ore Pile	Sample	X	X
16081020	OP01SS0.5	8/9/2016	Soil/Tailings	Ore Processing Area	Sample	X	X

Key:

SB	subsurface soil
SSE	surface soil
TP	Test Pit
Sb	Antimony
As	Arsenic
Hg	Mercury
SSE	Selective Sequential Extraction

Table 5

Test Pit Sampling and Field Screening Results Summary
Opalite Mine Removal Assessment
Malheur County, Oregon

Test Pit	Site Feature / Location	Depth (ft bgs)	EPA Sample ID	Location ID	XRF and Laboratory Sample Results[1]									Jerome J505 Hg Screening Results			Lithologic Description
					XRF Mercury (ppm)	Laboratory Total Mercury[2] Conc. (mg/kg)	Laboratory Total Mercury[2] Qual.	XRF Arsenic (ppm)	Laboratory Total Arsenic[2] Conc. (mg/kg)	Laboratory Total Arsenic[2] Qual.	XRF Antimony (ppm)	Laboratory Total Antimony[2] Conc. (mg/kg)	Laboratory Total Antimony[2] Qual.	Breathing Zone (µg/m^3)	Excavated Material (µg/m^3)	Test Pit (µg/m^3)	
				RSL - Residential[3]	11			0.68			3.1			ACGIH TLV: 25 µg/m^3			
				RSL - Industrial[3]	46			3			470						
				RML - Residential[3]	33			68			94						
				RML - Industrial[3]	140			300			1400						
1	Ore Processing Area - NW of Concrete Slab	1	NA	NA	255	--		85.1	--		63	--		--	--	9.9	Buff-colored, mixed sands and fines with 50% gravel to cobble.
		2.5			146	--		58.3	--		40	--		1.6	--	60	Weathered bedrock. Buff-colored silt and sand, moist. Thin sedimentary layering of alternating buff and brounw layers. Soft.
		3.5			144	--		95.9	--		50	--		18	--	40	Same as above.
		4.5			116	--		80.3	--		26	--		5.2	33	25	Same as above except moderately to well indurated.
		5			126	--		46.4	--		22	--		0	21.9	--	Same as above.
2	Ore Processing Area - NE of Concrete Slab	1.5	16081001	TP02SB1.5	194	396	JL	70.7	47.3	JL	35	4.8	JL	0.2	22	--	Weathered bedrock as described in Test Pit 1.
		2.5	16081002	TP02SB2.5	153	90.7	JL	82.3	25.6	JL	37	2.0	JL	0.7	43	90	Same as above.
3	Ore Processing Area - NE	0.5	16081003	TP03SS0.5	47	76.2	JL	31.5	36.5	JL	<LOD	1.4	JL	--	--	--	Not described.
		1.5	16081004	TP03SB1.5	33.8	49	JL	19.6	29.8	JL	<LOD	7.1	JL	0	0.2	1.2	Weathered bedrock as described in Test Pit 1.
4	Ore Processing Area - S of Concrete Rubble	0.5	16081005	TP04SS0.5	72	198	JL	90.7	52.2	JL	237	2.4	JL	--	--	--	Not described.
		2.5	16081006	TP04SB2.5	111	135	JL	132.3	95.1	JL	43	3.0	JL	1.4	5.7	7.7	Weathered bedrock as described in Test Pit 1.
		3.5	16081007	TP04SB3.5	100	221	JL	134.9	98.6	JL	29	2.3	JL	3	33	4.7	Same as above.
5	Ore Processing Area - NE of Concrete Structure	2	16081008 / 16081022	TP05SB02	361	776 / 413	JL / JL	119	44.5 / 60.5	JL / JL	139	4.4 / 6.8	JL / JL	0.2	6.3	1.7	Not described.
		4	16081009	TP05SB04	136	249	JL	82.8	30.8	JL	48	2.2	JL	0	1	5.4	Not described.
		5	16081010	TP05SB05	94	254	JL	40.9	39.2	JL	25	3.2	JL	0.3	5	10	Not described.
		7	16081011	TP05SB07	461	643	JL	88	41.2		73	3.1	JL	4.5	14.9	7.1	Weathered bedrock as described in Test Pit 1.
		8	16081012	TP05SB08	74	118	JL	56.4	32		33	1.6	JL	0.8	5.9	4.7	Refusal in weathered bedrock.
6	Ore Processing Area - Adjacent to Access Road	3	16081013 / 16081021	TP06SB03	3227	4580 / 4090	JL	551	555 / 670	-- / JL	1344	78.7 / 176	JL	17.1	99	167	Not described.
		4	16081014	TP06SB04	1221	131	JL	621	475		1765	75.1	JL	5.6	440	273	Not described.
		6	16081015	TP06SB06	1669	761	JL	162	23.3		460	3.3	JL	2	>500	200	Fill consisting of tan to dark brown sand, chunks of brick, wood, concrete.
		7	16081016	TP06SB07	648	2520	JL	129.8	79.2		140	15.2	JL	3.9	48	211	Same as above.
		8	16081017	TP06SB08	1639	5360	JL	362	268		638	36.6	JL	73.6	154	256	Same as above.

Table 5

Test Pit Sampling and Field Screening Results Summary
Opalite Mine Removal Assessment
Malheur County, Oregon

Test Pit	Site Feature / Location	Depth (ft bgs)	EPA Sample ID	Location ID	XRF and Laboratory Sample Results[1]									Jerome J505 Hg Screening Results			Lithologic Description
					XRF Mercury (ppm)	Laboratory Total Mercury[2]		XRF Arsenic (ppm)	Laboratory Total Arsenic[2]		XRF Antimony (ppm)	Laboratory Total Antimony[2]		Breathing Zone ($\mu g/m^3$)	Excavated Material ($\mu g/m^3$)	Test Pit ($\mu g/m^3$)	
						Conc. (mg/kg)	Qual.		Conc. (mg/kg)	Qual.		Conc. (mg/kg)	Qual.				
				RSL - Residential[3]		11			0.68			3.1		ACGIH TLV: 25 $\mu g/m^3$			
				RSL - Industrial[3]		46			3			470					
				RML - Residential[3]		33			68			94					
				RML - Industrial[3]		140			300			1400					
7	Southern Burned Ore Pile	Pit wall			70.06	--		596.84	--		480.2	--		6.6	2.4	--	Not described.
		Surface of tailings adjacent to pit	16081018	TP07SB05	59	54.8	JL	790	486		1290	37.8	JL	--	--	--	Not described.
8	Northern Burned Ore Pile	Surface of tailings adjacent to pit	16081019	TP08SB05	102	43.3	JL	53.7	44.1		57	1.3	JL	0.2		5.7	Not described.
SS	Small pile of gray silty material west of road in Ore Processing Area.		16081020	OP01SS0.5	NA	2700	JL	NA	62.5		NA	2.2	JL	--	--	--	Gray silty material.

[1] XRF results for Test Pits 2 through 8 are for samples collected from material excavated from the specified depth interval and screened ex situ. XRF results for Test Pit 1 were screened in situ.
[2] Laboratory samples analyzed for total mercury by EPA Method 7471B, and total arsenic and antimony by EPA Method 6010B.
[3] RSL and RML values are for Mercury (elemental); Arsenic, Inorganic; and Antimony (metallic).

Key:

--	Not Available/No Sample Collected
ACGIH	American Conference of Governmental Industrial Hygienists
bgs	below ground surface
Hg	mercury
LOD	Limit of Detection
mg/kg	milligrams per kilogram
ppm	parts per million
RML	Removal Management Level
RSL	Regional Screening Levels
Qual.	Laboratory data qualifier
SB	subsurface sample
SS	surface sample
TLV	Threshold Limit Value
TP	Test Pit
$\mu g/m^3$	microgram per cubic meter
	Highlighted value exceeds listed screening levels

Table 6

Mercury Selective Sequential Extraction Results
Opalite Mine Removal Assessment
Malheur County, Oregon

SSE Fraction	Extractant	Fraction Description	Typical Mercury Compounds Extracted in Fraction	Units	Sample ID and Location Description			
					TP06SB06 Test Pit - Ore Processing Area	**TP07SB05** Test Pit - Southern Burned Ore Pile	**TP08SB05** Test Pit - Northern Burned Ore Pile	**OP01SS0.5** Ore Processing Area
Fraction 0 (F0)	Ambient Temperature Gaseous Purging	Vapor Equilibrium	Free Hg^0	mg/kg	58.4	0.00309	0.00624	1.83
Fraction 1 (F1)	De-ionized Water	Water Soluble	Water-soluble Hg salts such as $HgCl_2$, $HgSO_4$	mg/kg	224	1.69	3.54	158
Fraction 2 (F2)	pH 2 HCl/HO Ac	Weak Acid Soluble ("Stomach Acid Soluble")	Low-pH soluble Hg salts including HgO	mg/kg	446	1.08	6.24	471
Fraction 3 (F3)	1 N KOH	Organo-Complexed	Organic-bound Hg compounds (e.g., Hg-humics), Hg_2Cl_2	mg/kg	131	0.87	2.74	168
Fraction 4 (F4)	12 N HNO3	Strong-Complexed	All other non-sulfide or silicate mimineral-bound compounds. May include amalgamated Hg^0	mg/kg	764	9.85	10.9	220
Fraction 5 (F5)	Aqua Regia	Sulfide Mineral-bound	Sulfide mineral-bound Hg (HgS, m-HgS); includes HgSe and Hg amalgams with noble metals if present.	mg/kg	859	55.7	17.1	483
Fraction 6 (F6)	Agua Regia and Hydrofluoric Acid	Silicate or Aluminosilicate Mineral-bound	Hg in silicate or aluminosilicate crystal lattice	mg/kg	133	25.6	112	70.2
Calcualted Total Mercury (Sum of Fractions F0 threough F6) and Total Mercury								
			Calculated Total Mercury - Sum of Fractions F0 through F6	mg/kg	2,615.4	94.8	152.5	1,572
			Total Mercury (EPA 1631) - Separate Aliquot	mg/kg	2,200	69.8	142	1,960

Key:

HCl	Hydrochloric acid
Hg	Mercury
Hg^0	Elemental mercury
Hg_2Cl_2	Mercurous chloride
$HgCl_2$	Mercuric chloride
HgO	Mercuric oxide
HgS	Cinnabar
HgSe	Mercuric selenide
$HgSO_4$	Mercuric sulfate
HNO_3	Nitric acid
HOAc	Acetic acid
KOH	Potassium hydroxide
mg/kg	miligrams per kilogram
m-HgS	Metacinnabar
N	Normal
SSE	Selective Sequential Extraction

Table 7

Preliminary Removal Assessment - In Situ XRF Screening Results
Opalite Mine
Malheur County, Oregon

In Situ XRF Screening Location	Location Description	In Situ XRF Screening Results (ppm)		
		Mercury	Arsenic	Antimony
	RSL - Residential[1]	11	0.68	3.1
	RSL - Industrial[1]	46	3	470
	RML - Residential[1]	33	68	94
	RML - Industrial[1]	140	300	1400
EPA-11	Ore Processing Area	233	212	78
EPA-12	Ore Processing Area	123	88	41
EPA-13	Ore Processing Area	37	26	22
EPA-15	Ore Processing Area - Access Road	1862	73	42
EPA-19	Ore Processing Area - Access Road	758	255	237
EPA-20	Ore Processing Area	119	192	119
EPA-21	Ore Processing Area - Near Test Pit 3	30	76	23
EPA-31	Ore Processing Area - Near Remains of Structure	36	71	32
EPA-32	Ore Processing Area - Near Remains of Structure	480	231	141
EPA-33	Ore Processing Area - Near Remains of Structure	3418	726	273
EPA-34	Ore Processing Area - Near Remains of Structure	362	191	170
EPA-35	Ore Processing Area - Near Remains of Structure	782	161	163
EPA-36	Ore Processing Area - Near Remains of Structure	207	55	70
EPA-37	Ore Processing Area - Near Remains of Structure	1114	265	277
EPA-38	Ore Processing Area - Near Remains of Structure	479	85	127
EPA-39	Ore Processing Area - Near Remains of Structure	316	207	345
EPA-41	Ore Processing Area - Near Remains of Structure	369	85	67
EPA-42	Ore Processing Area - Near Remains of Structure	129	68	42
EPA-55	Ore Processing Area	353	223	230
EPA-43	South of Ore Processing Area - Grey Mine Waste	474	117	105
EPA-44	South of Ore Processing Area - Grey Mine Waste	355	3059	647
EPA-45	South of Ore Processing Area - Grey Mine Waste	916	4667	363
EPA-46	South of Ore Processing Area - Red Mine Waste	83	999	1199
EPA-47	South of Ore Processing Area - Red Mine Waste	96	1570	1350
EPA-48	South of Ore Processing Area - Red Mine Waste	139	137	210
EPA-49	South of Ore Processing Area - Red Mine Waste	30	1110	2123
EPA-51	South of Ore Processing Area - Red Mine Waste	25	1159	1748
EPA-52	South of Ore Processing Area - Red Mine Waste	43	983	1120
EPA-53	South of Ore Processing Area - White Mine Waste	1290	3227	592
EPA-54	South of Ore Processing Area - White Mine Waste	438	1511	1087
ODEQ-68	Glory Hole	1263	160	187
ODEQ-69	Glory Hole	381	12	<LOD

Table 7

Preliminary Removal Assessment - In Situ XRF Screening Results
Opalite Mine
Malheur County, Oregon

In Situ XRF Screening Location	Location Description	In Situ XRF Screening Results (ppm)		
		Mercury	Arsenic	Antimony

[1] **RSL and RML values are for Mercury (elemental); Arsenic, Inorganic; and Antimony (metallic).**

Key:	
EPA	Environmental Protection Agency
LOD	Limit of Detection
ODEQ	Oregon Department of Environmental Quality
ppm	parts per million
mg/kg	milligrams per kilogram
RML	Regional Removal Management Level
RSL	Regional Screening Levels
	Highlighted cells exceed listed screening levels.

Table 8

In Situ XRF Screening: Potential Overland Drainage Pathways
Opalite Mine Removal Assessment
Malheur County, Oregon

Location ID	XRF Results (ppm)			Location Description
	Mercury	Arsenic	Antimony	
RSL - Residential[1]	11	0.68	3.1	
RSL - Industrial[1]	46	3	470	
RML - Residential[1]	33	68	94	
RML - Industrial[1]	140	300	1400	
Downgradient of Northern Burned Ore Pile				
ODEQ-24	27	44	<LOD	Up 20 feet from road in slight wash headed towards Northern Burned Ore Pile.
ODEQ-25	94	24	<LOD	White gravel area of apparent tailings near the foot of the Northern Burned Ore Pile.
ODEQ-26	37	55	<LOD	Wash immediately below Northern Burned Ore Pile.
Downgradient of Southern Burned Ore Pile				
ODEQ-27	84	113	<LOD	Roadbed immediately south of junction of spur heading up to ore processing area.
ODEQ-28	58	179	<LOD	Pink gravel on side of road.
ODEQ-29	49	83	<LOD	Wash 35 feet from base of the Southern Burned Ore Pile.
ODEQ-30	68	555	1321	Side of lower portion of the Southern Burned Ore Pile.
ODEQ-31	62	21	<LOD	Area of gravelly soil east of road.
ODEQ-32	<LOD	31	<LOD	Wash south of Southern Burned Ore Pile.
Downgradient of Road between Opalite Mine and Mine Creek				
ODEQ-17	<LOD	37	<LOD	SE road wash to Mine Creek.
ODEQ-18	32	39	<LOD	SE road wash to Mine Creek.
ODEQ-19	27	49	<LOD	SE road wash to Mine Creek.
ODEQ-20	21	39	<LOD	Dry wash between road and Mine Creek.
ODEQ-21	<LOD	33	<LOD	Dry wash between road and Mine Creek.
ODEQ-22	<LOD	<LOD	<LOD	Dry wash between road and Mine Creek upsteam of confluence with Mine Creek.
ODEQ-23	<LOD	<LOD	<LOD	Mine Creek downstream of confluence dry wash.

[1] RSL and RML values are for Mercury (elemental); Arsenic, Inorganic; and Antimony (metallic).

Key:	
LOD	Limit of Detection
ODEQ	Oregon Department of Environmental Quality
ppm	parts per million
mg/kg	milligrams per kilogram
RML	Regional Removal Management Level
RSL	Regional Screening Levels
	Highlighted cells exceed listed screening levels

ATTACHMENT 1
Photographic Documentation

This page intentionally left blank.

OPALITE MINE SITE
Malheur County, Oregon

TDD Number: 16-03-0008
Photographed by: Manique Talaia-Murray (MT), Steve Hall (SH)

Photo 1 Continuous screening for mercury (Hg) vapor in "Concrete Rubble" area. Highest value = 0.2 ug/m^3.

Direction: *Northwest* *Date: 8/9/16* *Time: 10:58* *Taken by: MT*

Photo 2 Northern concrete slab/rubble.

Direction: *South* *Date: 8/9/16* *Time: 11:21* *Taken by: MT*

Photo 3 Discrete sampling for mercury vapor in buff sand/debris northeast of concrete slab. Reading = 0.16 ug/m^3.

Direction: *Southeast* *Date: 8/9/16* *Time: 11:23* *Taken by: MT*

Photo 4 Coarse/angular, reddish rock pile/collection of pipe fragments, uphill and northeast of concrete slabs. Reading = 0.09 ug/m^3.

Direction: *Northwest* *Date: 8/9/16* *Time: 11:33* *Taken by: MT*

Photo 5 Discrete sampling for mercury vapor upgradient of Tunnel 2. Reading = 0.04 ug/m^3.

Direction: *Southwest* *Date: 8/9/16* *Time: 11:38* *Taken by: MT*

Photo 6 Discrete sampling for mercury vapor at opening of Adit/Tunnel 2. Reading = 0.12 ug/m^3.

Direction: *Northeast* *Date: 8/9/16* *Time: 11:41* *Taken by: MT*

Photo 7 Discrete sampling for mercury vapor west of Tunnel 2 opening. Material on ground is sandy/silt with angular pieces of debris and rock. Reading = 0.1 ug/m^3.

Direction: *East* *Date: 8/9/16* *Time: 11:46* *Taken by: MT*

Photo 8 Excavator navigates the access road to the Ore Processing Area.

Direction: *South* *Date: 8/9/16* *Time: 11:47* *Taken by: SH*

Photo 9 Discrete sampling for mercury vapor halfway up slope due north of waste rock pit. Reading = 0.04 ug/m^3.

Direction: *Southwest* *Date: 8/9/16* *Time: 11:51* *Taken by: MT*

Photo 10 Structural remains in the Ore Processing Area and access road.

Date: *8/9/16* *Time: 11:52* *Taken by:* *SH*

Photo 11 Discrete sampling for mercury vapor on upper road north of waste rock pit. Similar sandy/silt material as previously. Reading = 0.06 ug/m^3.

Direction: *Southwest* *Date: 8/9/16* *Time: 11:57* *Taken by: MT*

Photo 12 Discrete sampling for mercury vapor on rock mound approximately 300 feet north of Northern Burned Ore Pile. Reading = 0.04 ug/m^3.

Direction: *Southwest* *Date: 8/9/16* *Time: 12:03* *Taken by: MT*

Photo 13 Discrete sampling for mercury vapor approximately 50' upslope of previous sample on pile of waste rock below bluffs. Reading = 0.03 ug/m^3.

Direction: *West* *Date: 8/9/16* *Time: 12:09* *Taken by: MT*

Photo 14 Discrete sampling for mercury vapor above collapsed Tunnel 1 on a pile of red rock.

Direction: *South* *Date: 8/9/16* *Time: 12:21* *Taken by: MT*

Photo 15 Continuous screening for mercury vapor along northwest arm of rock pile along multicolored rock piles seen in this photo. Highest value = 0.08 ug/m^3.

Direction: *Southeast* *Date: 8/9/16* *Time: 12:33* *Taken by: MT*

Photo 16 Northern and Southern Burned Ore Piles and structures in Ore Processing Area.

Direction: *Southwest* *Date: 8/9/16* *Time: 12:48* *Taken by: SH*

Photo 17 Northern and Southern Burned Ore Piles and structures in Ore Processing Area.

Direction: *Southwest* *Date: 8/9/16* *Time: 12:48* *Taken by: SH*

Photo 18 Northern and Southern Burned Ore Piles and structures in Ore Processing Area.

Direction: *Southwest* *Date: 8/9/16* *Time: 12:51* *Taken by: SH*

Photo 19 DataRam in operation during test pit excavation.

Direction: *Northeast* *Date: 8/9/16* *Time: 12:52* *Taken by: SH*

Photo 20 Ore Processing Area structures and rubble. Northern and Southern Burned Ore Piles in middle-distance.

Direction: *Southwest* *Date: 8/9/16* *Time: 12:55* *Taken by: SH*

Photo 21 Preparing to excavate Test Pit 1.

Direction: *North* *Date: 8/9/16* *Time: 13:12* *Taken by: MT*

Photo 22 Mercury vapor screening in ore processing area test pit.

Direction: *Down* *Date: 8/9/16* *Time: 13:19* *Taken by: SH*

Photo 23 Geologic logging, Hg vapor screening and X-Ray Fluorescence Analyzer (XRF) screening in Test Pit 2.

Direction: *Southeast* *Date: 8/9/16* *Time: 13:32* *Taken by: SH*

Photo 24 Geologic logging, Hg vapor screening and XRF screening in Test Pit 2.

Direction: *Northeast* *Date: 8/9/16* *Time: 13:37* *Taken by: SH*

Photo 25 Geologic logging, Hg vapor screening and XRF screening in Test Pit 2.

Direction: *Northeast* *Date: 8/9/16* *Time: 13:38* *Taken by: SH*

Photo 26 Lacustrine sedimentary deposits (bedrock).

Direction: *Down* *Date: 8/9/16* *Time: 14:16* *Taken by: SH*

Photo 27 Geologic logging at Test Pit 3.

Direction: *Northeast* *Date: 8/9/16* *Time: 14:16* *Taken by: SH*

Photo 28 Sampling and Hg vapor analysis at Test Pit 3.

Direction: *Southeast* *Date: 8/9/16* *Time: 14:16* *Taken by: SH*

Photo 29 Mercury vapor screening at Test Pit 3.

Direction: Northeast Date: 8/9/16 Time: 14:32 Taken by: SH

Photo 30 Excavator digging Test Pit 4.

Direction: Southeast Date: 8/9/16 Time: 15:06 Taken by: SH

Photo 31 XRF screening near Southern Burned Ore Pile.

Direction: Southeast Date: 8/9/16 Time: 15:06 Taken by: SH:

Photo 32 Mercury vapor screening at Test Pit 4.

Direction: Southeast Date: 8/9/16 Time: 15:06 Taken by: SH

Photo 33 Mercury vapor screening at Test Pit 4.

Direction: Down *Date: 8/9/16* *Time: 15:09* *Taken by: SH*

Photo 34 Test Pit 4. Soil horizon at 3.5 feet below ground surface.

Direction: Down *Date: 8/9/16* *Time: 15:10* *Taken by: SH*

Photo 35 Test Pit 4. Soil horizon at 3.5 feet below ground surface.

Direction: Down *Date: 8/9/16* *Time: 15:10* *Taken by: SH*

Photo 36 Visual assessment of relict ore processing machinery.

Direction: Southeast *Date: 8/9/16* *Time: 15:35* *Taken by: SH*

Photo 37 Ore processing area structures from access road.

Direction: Northeast Date: 8/9/16 Time: 15:36 Taken by: SH

Photo 38 Excavator maneuvers to Test Pit 5.

Direction: Southeast Date: 8/9/16 Time: 15:45 Taken by: SH

Photo 39 Excavation begins at Test Pit 5.

Direction: Southeast Date: 8/9/16 Time: 15:48 Taken by: SH

Photo 40 XRF screening of Test Pit 5 material by Oregon Department of Environmental Quality (ODEQ).

Direction: Down Date: 8/9/16 Time: 15:49 Taken by: SH

Photo 41 Test Pit 5.

Direction: South *Date: 8/9/16* *Time: 16:06* *Taken by: SH*

Photo 42 Test Pit 5.

Direction: Down *Date: 8/9/16* *Time: 16:07* *Taken by: SH*

Photo 43 Excavation of Test Pit 5.

Direction: South *Date: 8/9/16* *Time: 16:49* *Taken by: SH*

Photo 44 Excavation of Test Pit 6 and XRF screening of material by ODEQ.

Direction: South *Date: 8/9/16* *Time: 16:49* *Taken by: SH*

Photo 45 Mercury vapor screening and sampling at Test Pit 6.

Direction: *South* *Date: 8/9/16* *Time: 16:52* *Taken by: SH*

Photo 46 Sooty layer in Test Pit 6 stratigraphy.

Direction: *Down* *Date: 8/9/16* *Time: 17:09* *Taken by: SH*

Photo 47 Mercury vapor screening and sampling at Test Pit 6.

Direction: *South* *Date: 8/9/16* *Time: 17:13* *Taken by: SH*

Photo 48 Sampling of grey soot on western side of ore processing area access road.

Direction: *Southwest* *Date: 8/9/16* *Time: 17:18* *Taken by: SH*

Photo 49 Excavating Test Pit 7 from Southern Burned Ore Pile.

Direction: Southeast Date: 8/9/16 Time: 17:31 Taken by: SH

Photo 50 Excavating Test Pit 7 in Southern Burned Ore Pile.

Direction: Southeast Date: 8/9/16 Time: 17:31 Taken by: SH

Photo 51 Excavating Test Pit 8 in Northern Burned Ore Pile.

Direction: Southwest Date: 8/9/16 Time: 17:48 Taken by: SH

Photo 52 Excavating Test Pit 8 in Northern Burned Ore Pile.

Direction: Southwest Date: 8/9/16 Time: 17:48 Taken by: SH

This page intentionally left blank.

ATTACHMENT 2
Analytical Results

This page intentionally left blank.

ecology and environment, inc.
Global Environmental Specialists
720 Third Avenue, Suite 1700
Seattle, Washington 98104
Tel: (206) 624-9537, Fax: (206) 621-9832

MEMORANDUM

DATE: September 19, 2016

TO: Steve Hall, START-IV Project Manager, E & E, Seattle, Washington

FROM: Mark Woodke, START-IV START-IV Chemist, E & E, Seattle, Washington MW

SUBJ: **Inorganic Data Quality Assurance Review,**
Opalite Mine Removal Assessment, Malheur County, Oregon

REF: TDD: 16-03-0008 PAN: 1004530.0004.149.01

The data quality assurance review of 22 soil samples collected from the Opalite Mine Removal Assessment site in Malheur County, Oregon, has been completed. Antimony and arsenic (EPA Method 6010C) analyses were performed by A&B Labs, Inc., Houston, Texas, and mercury (EPA Method 7471A) analyses were performed by Xenco Laboratories, Inc., Stafford, Texas. All sample analyses were evaluated following EPA's Stage 2 and/or 4 Data Validation Electronic and/or Manual Process (S2B/4VE/M).

The samples were numbered:

16081001	16081002	16081003	16081004	16081005
16081006	16081007	16081008	16081009	16081010
16081011	16081012	16081013	16081014	16081015
16081016	16081017	16081018	16081019	16081020
16081021	16081022			

Data Qualifications:

1. **Sample Holding Times: Satisfactory.**

The samples were received at 10.8°C, exceeding mercury QC limits of < 6°C. Associated mercury results were qualified as estimated quantities with a low bias (JL or UJL). The samples were collected on August 9, 2016, and were analyzed by September 6, 2016, therefore meeting QC criteria of less than 6 months between collection, extraction, and analysis (28 days for mercury).

2. **Initial and Continuing Calibration: Acceptable.**

A minimum of one calibration standard and a blank were analyzed at the beginning of the ICP analysis sequence and after every 10 samples. No results were greater than 110% of the highest calibration standard. All ICP recoveries were within the QC limits. All AA recoveries were within QC limits. All cyanide recoveries were within the QC limits.

3. **Blanks: Acceptable.**

A preparation blank was analyzed for each 20 samples or per matrix per concentration level. Blanks were analyzed after each Initial or Continuing Calibration Verification. There were no detections in

any blanks.

4. ICP Interference Check Sample: Acceptable.

An Interference Check Sample (ICS) was analyzed at the beginning and end of each sequence or at least twice every 8 hours, whichever was more frequent. All ICS (solution AB) results were within QC limits of 80% - 120% recovery.

5. Precision and Bias Determination: Not Performed.

Samples necessary to determine precision and bias were not provided to the laboratory. All results were flagged "PND" (Precision Not Determined) and "RND" (Recovery Not Determined), although the flags do not appear on the data sheets.

6. Performance Evaluation Sample Analysis: Not Provided.

Performance evaluation samples were not provided to the laboratory.

7. ICP Serial Dilution: Acceptable.

A serial dilution analysis was performed per matrix per concentration or per sample delivery group, whichever was more frequent. All serial dilution results were within QC limits.

8. Matrix Spike Analysis: Satisfactory.

A matrix spike analysis was performed per SDG or per matrix per concentration level, whichever was more frequent. Spike and spike duplicate recoveries were within the QC limits except antimony and arsenic with low recoveries associated with all samples except arsenic in samples 16081011 through 16081020. Results associated with the low recovery outliers were qualified as estimated quantities with a low bias (JL or UJL). The SDG mercury spike results were not applicable as the native sample results were more than four times higher than the spike amount added to the samples.

9. Duplicate Analysis: Acceptable.

A laboratory duplicate analysis was performed per SDG or per matrix per concentration level, whichever was more frequent. All duplicate results were within QC limits.

10. Laboratory Control Sample Analysis: Acceptable.

A Laboratory Control Sample (LCS) was analyzed per SDG per matrix. All LCS results were within the established control limits.

11. Overall Assessment of Data for Use

The reviewer used professional judgment to apply a single bias qualifier when more than one bias qualifier was applicable to an individual estimated sample result. The results were dry weight corrected. Dry weight analyses were performed after holding time limits; no additional actions were taken based on these discrepancies.

The overall usefulness of the data is based on the criteria outlined in the Site-Specific Sampling Plan and/or Sampling and Quality Assurance Plan, the OSWER Directive "Quality Assurance/Quality Control Guidance for Removal Activities, Data Validation Procedures" (EPA/540/G-90/004), the analytical methods, and, when applicable, the Office of Emergency and Remedial Response Publication

"National Functional Guidelines for Inorganic Superfund Data Review, August 2014". Based upon the information provided, the data are acceptable for use with the above stated data qualifications.

Data Qualifiers and Definitions

U - The analyte was analyzed for, but was not detected above the level of the reported sample quantitation limit.

J - The result is an estimated quantity. The associated numerical value is the approximate concentration of the analyte in the sample.

JH - The result is an estimated quantity, but the result may be biased high.

JL - The result is an estimated quantity, but the result may be biased low.

JK - The result is an estimated quantity, but the result may have an unknown bias.

JQ - The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample with an unknown direction of bias and falls between the MDL and the Minimum (or Practical) Quantitation Limit (MQL, PQL).

UJ - The analyte was analyzed for, but was not detected. The reported quantitation limit is approximate and may be inaccurate or imprecise.

R - The data are unusable. The sample results are rejected due to serious deficiencies in meeting QC criteria. The analyte may or may not be present in the sample.

Certificate of Analytical Results 536087

A & B Labs, Houston, TX

10ZZ

Sample Id:	**16081001**	Matrix:	Soil	Date Received:	09.01.16 16.30
Lab Sample Id:	536087-001	Date Collected:	08.09.16 00.00		
Analytical Method:	Mercury by SW-846 7471A			Prep Method:	SW7471P
Tech:	MJP			% Moisture:	19.5
Analyst:	DEP	Date Prep:	09.02.16 09.30	Basis:	Dry Weight
Seq Number:	1001179				

Parameter	Cas Number	Result	RL	MDL	Units	Analysis Date	Flag	Dil
Mercury	7439-97-6	**396** JL	22.2	4.26	mg/kg	09.02.16 14.54		1000

Certificate of Analytical Results 536087

A & B Labs, Houston, TX

10ZZ

Sample Id:	**16081002**	Matrix:	Soil	Date Received:	09.01.16 16.30
Lab Sample Id:	536087-002	Date Collected:	08.09.16 00.00		
Analytical Method:	Mercury by SW-846 7471A			Prep Method:	SW7471P
Tech:	MJP			% Moisture:	20.2
Analyst:	DEP	Date Prep:	09.02.16 09.30	Basis:	Dry Weight
Seq Number:	1001179				

Parameter	Cas Number	Result	RL	MDL	Units	Analysis Date	Flag	Dil
Mercury	7439-97-6	**90.7** J	11.0	2.11	mg/kg	09.02.16 15.01		500

MW 9-9-16

Certificate of Analytical Results 536087

A & B Labs, Houston, TX

10ZZ

Sample Id:	**16081003**	Matrix:	Soil	Date Received:	09.01.16 16.30
Lab Sample Id:	536087-003	Date Collected:	08.09.16 00.00		
Analytical Method:	Mercury by SW-846 7471A			Prep Method:	SW7471P
Tech:	MJP			% Moisture:	3.9
Analyst:	DEP	Date Prep:	09.02.16 09.30	Basis:	Dry Weight
Seq Number:	1001179				

Parameter	Cas Number	Result	RL	MDL	Units	Analysis Date	Flag	Dil
Mercury	7439-97-6	**76.2** J	9.29	1.79	mg/kg	09.02.16 15.05		500

Certificate of Analytical Results 536087

A & B Labs, Houston, TX

10ZZ

Sample Id:	**16081004**	Matrix:	Soil	Date Received:	09.01.16 16.30
Lab Sample Id:	536087-004	Date Collected:	08.09.16 00.00		
Analytical Method:	Mercury by SW-846 7471A			Prep Method:	SW7471P
Tech:	MJP			% Moisture:	24.2
Analyst:	DEP	Date Prep:	09.02.16 09.30	Basis:	Dry Weight
Seq Number:	1001179				

Parameter	Cas Number	Result	RL	MDL	Units	Analysis Date	Flag	Dil
Mercury	7439-97-6	**49.0** JL	2.24	0.430	mg/kg	09.02.16 15.59		100

Certificate of Analytical Results 536087

A & B Labs, Houston, TX

10ZZ

Sample Id:	**16081005**	Matrix:	Soil	Date Received:	09.01.16 16.30
Lab Sample Id:	536087-005	Date Collected:	08.09.16 00.00		
Analytical Method:	Mercury by SW-846 7471A			Prep Method:	SW7471P
Tech:	MJP			% Moisture:	2.7
Analyst:	DEP	Date Prep:	09.02.16 09.30	Basis:	Dry Weight
Seq Number:	1001179				

Parameter	Cas Number	Result	RL	MDL	Units	Analysis Date	Flag	Dil
Mercury	7439-97-6	**198** JL	9.18	1.76	mg/kg	09.02.16 15.08		500

Certificate of Analytical Results 536087

A & B Labs, Houston, TX

10ZZ

Sample Id:	**16081006**	Matrix:	Soil	Date Received:	09.01.16 16.30
Lab Sample Id:	536087-006	Date Collected:	08.09.16 00.00		
Analytical Method:	Mercury by SW-846 7471A			Prep Method:	SW7471P
Tech:	MJP			% Moisture:	20.8
Analyst:	DEP	Date Prep:	09.02.16 09.30	Basis:	Dry Weight
Seq Number:	1001179				

Parameter	Cas Number	Result	RL	MDL	Units	Analysis Date	Flag	Dil
Mercury	7439-97-6	**135** JL	11.1	2.13	mg/kg	09.02.16 15.10		500

JMW 9/9/16

Certificate of Analytical Results 536087

A & B Labs, Houston, TX

10ZZ

Sample Id:	**16081007**	Matrix:	Soil	Date Received:	09.01.16 16.30
Lab Sample Id:	536087-007	Date Collected:	08.09.16 00.00		
Analytical Method:	Mercury by SW-846 7471A			Prep Method:	SW7471P
Tech:	MJP			% Moisture:	20.8
Analyst:	DEP	Date Prep:	09.02.16 09.30	Basis:	Dry Weight
Seq Number:	1001179				

Parameter	Cas Number	Result	RL	MDL	Units	Analysis Date	Flag	Dil
Mercury	7439-97-6	**221** JL	11.7	2.25	mg/kg	09.02.16 15.11		500

MW 9-19-16

Certificate of Analytical Results 536087

A & B Labs, Houston, TX

10ZZ

Sample Id:	**16081008**	Matrix:	Soil	Date Received:	09.01.16 16.30
Lab Sample Id:	536087-008	Date Collected:	08.09.16 00.00		
Analytical Method:	Mercury by SW-846 7471A			Prep Method:	SW7471P
Tech:	MJP			% Moisture:	11
Analyst:	DEP	Date Prep:	09.02.16 09.30	Basis:	Dry Weight
Seq Number:	1001179				

Parameter	Cas Number	Result	RL	MDL	Units	Analysis Date	Flag	Dil
Mercury	7439-97-6	**776** JL	50.2	9.64	mg/kg	09.02.16 16.02		2500

Final 1.001

9-9-16

Certificate of Analytical Results 536087

A & B Labs, Houston, TX

10ZZ

Sample Id:	**16081009**	Matrix:	Soil	Date Received:	09.01.16 16.30
Lab Sample Id:	536087-009	Date Collected:	08.09.16 00.00		
Analytical Method:	Mercury by SW-846 7471A			Prep Method:	SW7471P
Tech:	MJP			% Moisture:	14.8
Analyst:	DEP	Date Prep:	09.02.16 09.30	Basis:	Dry Weight
Seq Number:	1001179				

Parameter	Cas Number	Result	RL	MDL	Units	Analysis Date	Flag	Dil
Mercury	7439-97-6	**249** JL	10.5	2.01	mg/kg	09.02.16 15.14		500

Final 1.001

MW 9/9/16

Certificate of Analytical Results 536087

A & B Labs, Houston, TX

10ZZ

Sample Id:	**16081010**	Matrix:	Soil	Date Received:	09.01.16 16.30
Lab Sample Id:	536087-010	Date Collected:	08.09.16 00.00		
Analytical Method:	Mercury by SW-846 7471A			Prep Method:	SW7471P
Tech:	MJP			% Moisture:	19.6
Analyst:	DEP	Date Prep:	09.02.16 09.30	Basis:	Dry Weight
Seq Number:	1001179				

Parameter	Cas Number	Result	RL	MDL	Units	Analysis Date	Flag	Dil
Mercury	7439-97-6	**254** JL	10.7	2.06	mg/kg	09.02.16 15.15		500

MW 9/9/16

Certificate of Analytical Results 536087

A & B Labs, Houston, TX

10ZZ

Sample Id:	**16081011**	Matrix:	Soil	Date Received:	09.01.16 16.30
Lab Sample Id:	536087-011	Date Collected:	08.09.16 00.00		
Analytical Method:	Mercury by SW-846 7471A			Prep Method:	SW7471P
Tech:	MJP			% Moisture:	16
Analyst:	DEP	Date Prep:	09.02.16 09.30	Basis:	Dry Weight
Seq Number:	1001179				

Parameter	Cas Number	Result	RL	MDL	Units	Analysis Date	Flag	Dil
Mercury	7439-97-6	**643** JL	50.4	9.70	mg/kg	09.02.16 15.49		2500

JW 9-9-16

Certificate of Analytical Results 536087

A & B Labs, Houston, TX

10ZZ

Sample Id:	**16081012**	Matrix:	Soil	Date Received:	09.01.16 16.30
Lab Sample Id:	536087-012	Date Collected:	08.09.16 00.00		
Analytical Method:	Mercury by SW-846 7471A			Prep Method:	SW7471P
Tech:	MJP			% Moisture:	19.8
Analyst:	DEP	Date Prep:	09.02.16 09.30	Basis:	Dry Weight
Seq Number:	1001179				

Parameter	Cas Number	Result	RL	MDL	Units	Analysis Date	Flag	Dil
Mercury	7439-97-6	**118** JL	11.1	2.14	mg/kg	09.02.16 15.32	~~X~~ MW	500

Certificate of Analytical Results 536087

A & B Labs, Houston, TX

10ZZ

Sample Id:	**16081013**	Matrix:	Soil	Date Received:	09.01.16 16.30
Lab Sample Id:	536087-013	Date Collected:	08.09.16 00.00		
Analytical Method:	Mercury by SW-846 7471A			Prep Method:	SW7471P
Tech:	MJP			% Moisture:	18.3
Analyst:	DEP	Date Prep:	09.02.16 09.30	Basis:	Dry Weight
Seq Number:	1001179				

Parameter	Cas Number	Result	RL	MDL	Units	Analysis Date	Flag	Dil
Mercury	7439-97-6	**4580** JL	537	103	mg/kg	09.02.16 15.45		25000

Certificate of Analytical Results 536087

A & B Labs, Houston, TX

10ZZ

Sample Id:	**16081014**	Matrix:	Soil	Date Received:	09.01.16 16.30
Lab Sample Id:	536087-014	Date Collected:	08.09.16 00.00		
Analytical Method:	Mercury by SW-846 7471A			Prep Method:	SW7471P
Tech:	MJP			% Moisture:	18.6
Analyst:	DEP	Date Prep:	09.02.16 09.30	Basis:	Dry Weight
Seq Number:	1001179				

Parameter	Cas Number	Result	RL	MDL	Units	Analysis Date	Flag	Dil
Mercury	7439-97-6	**131** JL	10.8	2.07	mg/kg	09.02.16 15.46		500

MW 9/9/16

Certificate of Analytical Results 536087

A & B Labs, Houston, TX

10ZZ

Sample Id:	**16081015**	Matrix:	Soil	Date Received:	09.01.16 16.30
Lab Sample Id:	536087-015	Date Collected:	08.09.16 00.00		
Analytical Method:	Mercury by SW-846 7471A			Prep Method:	SW7471P
Tech:	MJP			% Moisture:	18.1
Analyst:	DEP	Date Prep:	09.02.16 09.30	Basis:	Dry Weight
Seq Number:	1001179				

Parameter	Cas Number	Result	RL	MDL	Units	Analysis Date	Flag	Dil
Mercury	7439-97-6	**761** JL	53.6	10.3	mg/kg	09.02.16 15.48		2500

Certificate of Analytical Results 536087

A & B Labs, Houston, TX

10ZZ

Sample Id:	**16081016**	Matrix:	Soil	Date Received:	09.01.16 16.30
Lab Sample Id:	536087-016	Date Collected:	08.09.16 00.00		
Analytical Method:	Mercury by SW-846 7471A			Prep Method:	SW7471P
Tech:	MJP			% Moisture:	16.5
Analyst:	DEP	Date Prep:	09.02.16 09.30	Basis:	Dry Weight
Seq Number:	1001179				

Parameter	Cas Number	Result	RL	MDL	Units	Analysis Date	Flag	Dil
Mercury	7439-97-6	**2520** JL	525	101	mg/kg	09.02.16 16.01		25000

Certificate of Analytical Results 536087

A & B Labs, Houston, TX

10ZZ

Sample Id:	**16081017**	Matrix:	Soil	Date Received:	09.01.16 16.30
Lab Sample Id:	536087-017	Date Collected:	08.09.16 00.00		
Analytical Method:	Mercury by SW-846 7471A			Prep Method:	SW7471P
Tech:	MJP			% Moisture:	13.9
Analyst:	DEP	Date Prep:	09.02.16 09.30	Basis:	Dry Weight
Seq Number:	1001179				

Parameter	Cas Number	Result	RL	MDL	Units	Analysis Date	Flag	Dil
Mercury	7439-97-6	**5360** JL	528	101	mg/kg	09.02.16 15.51		25000

MW 9-19-16

Certificate of Analytical Results 536087

A & B Labs, Houston, TX

10ZZ

Sample Id:	**16081018**	Matrix:	Soil	Date Received:	09.01.16 16.30
Lab Sample Id:	536087-018	Date Collected:	08.09.16 00.00		
Analytical Method:	Mercury by SW-846 7471A			Prep Method:	SW7471P
Tech:	MJP			% Moisture:	18.7
Analyst:	DEP	Date Prep:	09.02.16 09.30	Basis:	Dry Weight
Seq Number:	1001179				

Parameter	Cas Number	Result	RL	MDL	Units	Analysis Date	Flag	Dil
Mercury	7439-97-6	**54.8** JL	11.2	2.15	mg/kg	09.02.16 15.41		500

MW 9-9-16

Certificate of Analytical Results 536087

A & B Labs, Houston, TX

10ZZ

Sample Id:	**16081019**	Matrix:	Soil	Date Received:	09.01.16 16.30
Lab Sample Id:	536087-019	Date Collected:	08.09.16 00.00		
Analytical Method:	Mercury by SW-846 7471A			Prep Method:	SW7471P
Tech:	MJP			% Moisture:	10.3
Analyst:	DEP	Date Prep:	09.02.16 09.30	Basis:	Dry Weight
Seq Number:	1001179				

Parameter	Cas Number	Result	RL	MDL	Units	Analysis Date	Flag	Dil
Mercury	7439-97-6	**43.3** JL	1.99	0.383	mg/kg	09.02.16 15.56		100

MW 9-9-16

Certificate of Analytical Results 536087

A & B Labs, Houston, TX

10ZZ

Sample Id:	**16081020**	Matrix:	Soil	Date Received:	09.01.16 16.30
Lab Sample Id:	536087-020	Date Collected:	08.09.16 00.00		
Analytical Method:	Mercury by SW-846 7471A			Prep Method:	SW7471P
Tech:	MJP			% Moisture:	.9
Analyst:	DEP	Date Prep:	09.02.16 09.30	Basis:	Dry Weight
Seq Number:	1001179				

Parameter	Cas Number	Result	RL	MDL	Units	Analysis Date	Flag	Dil
Mercury	7439-97-6	**2700** JL	450	86.6	mg/kg	09.02.16 15.52		25000

JMW 9-9-16

Certificate of Analytical Results 536087

A & B Labs, Houston, TX

10ZZ

Sample Id:	**16081021**	Matrix:	Soil	Date Received:	09.01.16 16.30
Lab Sample Id:	536087-021	Date Collected:	08.09.16 00.00		
Analytical Method:	Mercury by SW-846 7471A			Prep Method:	SW7471P
Tech:	MJP			% Moisture:	16.6
Analyst:	DEP	Date Prep:	09.02.16 09.33	Basis:	Dry Weight
Seq Number:	1001204				

Parameter	Cas Number	Result	RL	MDL	Units	Analysis Date	Flag	Dil
Mercury	7439-97-6	**4090** JL	226	43.5	mg/kg	09.06.16 14.20		10000

MW 9-19-16

Certificate of Analytical Results 536087

A & B Labs, Houston, TX

10ZZ

Sample Id:	**16081022**	Matrix:	Soil	Date Received:	09.01.16 16.30
Lab Sample Id:	536087-022	Date Collected:	08.09.16 00.00		
Analytical Method:	Mercury by SW-846 7471A			Prep Method:	SW7471P
Tech:	MJP			% Moisture:	13.2
Analyst:	DEP	Date Prep:	09.02.16 09.33	Basis:	Dry Weight
Seq Number:	1001204				

Parameter	Cas Number	Result	RL	MDL	Units	Analysis Date	Flag	Dil
Mercury	7439-97-6	**413** JL	43.5	8.36	mg/kg	09.06.16 14.22		2000

MW 9-19-16

Certificate of Analysis 16080701

Inorganic Analysis Data Sheet

A&B Environmental Services, dba A&B Labs
SDG No.: 16080701
Matrix: Soil
% Solids: 80.5
Method: EPA 6010C
Analyst: SR Gade

Client: Ecology and Environment, Inc.
Sample: 16081001
Lab Sample ID: 16080701.01
Date Collected: 08/09/2016
Date Received: 08/11/2016 10:09
Date Analyzed: 08/13/2016 00:31

CAS NO.	COMPOUND	CONCENTRATION	UNITS	Q	D.F	RL	SRL
7440-36-0	Antimony	4.8	mg/Kg - Dry	JL	1	0.5	0.62
79-34-5	Arsenic	47.3	mg/Kg - Dry	JL	1	0.5	0.62

MW 9/9/16

Certificate of Analysis 16080701

Inorganic Analysis Data Sheet

A&B Environmental Services, dba A&B Labs
SDG No.: 16080701
Matrix: Soil
% Solids: 79.8
Method: EPA 6010C
Analyst: SR Gade

Client: Ecology and Environment, Inc.
Sample: 16081002
Lab Sample ID: 16080701.02
Date Collected: 08/09/2016
Date Received: 08/11/2016 10:09
Date Analyzed: 08/13/2016 00:36

CAS NO.	COMPOUND	CONCENTRATION	UNITS	Q	D.F	RL	SRL
7440-36-0	Antimony	2.0	mg/Kg - Dry	JL	1	0.5	0.62
79-34-5	Arsenic	25.6	mg/Kg - Dry	JL	1	0.5	0.62

JW 9/9/16

Certificate of Analysis 16080701

Inorganic Analysis Data Sheet

A&B Environmental Services, dba A&B Labs
SDG No.: 16080701
Matrix: Soil
% Solids: 96.1
Method: EPA 6010C
Analyst: SR Gade

Client: Ecology and Environment, Inc.
Sample: 16081003
Lab Sample ID: 16080701.03
Date Collected: 08/09/2016
Date Received: 08/11/2016 10:09
Date Analyzed: 08/13/2016 00:41

CAS NO.	COMPOUND	CONCENTRATION	UNITS	Q	D.F	RL	SRL
7440-36-0	Antimony	1.4	mg/Kg - Dry	JL	1	0.5	0.52
79-34-5	Arsenic	36.5	mg/Kg - Dry	JL	1	0.5	0.52

Certificate of Analysis 16080701

Inorganic Analysis Data Sheet

A&B Environmental Services, dba A&B Labs
SDG No.: 16080701
Matrix: Soil
% Solids: 75.8
Method: EPA 6010C
Analyst: SR Gade

Client: Ecology and Environment, Inc.
Sample: 16081004
Lab Sample ID: 16080701.04
Date Collected: 08/09/2016
Date Received: 08/11/2016 10:09
Date Analyzed: 08/13/2016 01:02

CAS NO.	COMPOUND	CONCENTRATION	UNITS	Q	D.F	RL	SRL
7440-36-0	Antimony	7.1	mg/Kg - Dry	JL	1	0.5	0.66
79-34-5	Arsenic	29.8	mg/Kg - Dry	JL	1	0.5	0.66

Certificate of Analysis 16080701

Inorganic Analysis Data Sheet

A&B Environmental Services, dba A&B Labs
SDG No.: 16080701
Matrix: Soil
% Solids: 97.3
Method: EPA 6010C
Analyst: SR Gade

Client: Ecology and Environment, Inc.
Sample: 16081005
Lab Sample ID: 16080701.05
Date Collected: 08/09/2016
Date Received: 08/11/2016 10:09
Date Analyzed: 08/13/2016 01:07

CAS NO.	COMPOUND	CONCENTRATION	UNITS	Q	D.F.	RL	SRL
7440-36-0	Antimony	2.4	mg/Kg - Dry	JL	1	0.5	0.51
79-34-5	Arsenic	52.2	mg/Kg - Dry	JL	1	0.5	0.51

Certificate of Analysis 16080701

Inorganic Analysis Data Sheet

A&B Environmental Services, dba A&B Labs
SDG No.: 16080701
Matrix: Soil
% Solids: 79.2
Method: EPA 6010C
Analyst: SR Gade

Client: Ecology and Environment, Inc.
Sample: 16081006
Lab Sample ID: 16080701.06
Date Collected: 08/09/2016
Date Received: 08/11/2016 10:09
Date Analyzed: 08/13/2016 01:12

CAS NO.	COMPOUND	CONCENTRATION	UNITS	Q	D.F	RL	SRL
7440-36-0	Antimony	3.0	mg/Kg - Dry	JL	1	0.5	0.63
79-34-5	Arsenic	95.1	mg/Kg - Dry	JL	1	0.5	0.63

8-19-16

Certificate of Analysis 16080701

Inorganic Analysis Data Sheet

A&B Environmental Services, dba A&B Labs
SDG No.: 16080701
Matrix: Soil
% Solids: 79.2
Method: EPA 6010C
Analyst: SR Gade

Client: Ecology and Environment, Inc.
Sample: 16081007
Lab Sample ID: 16080701.07
Date Collected: 08/09/2016
Date Received: 08/11/2016 10:09
Date Analyzed: 08/13/2016 01:17

CAS NO.	COMPOUND	CONCENTRATION	UNITS	Q	D.F	RL	SRL
7440-36-0	Antimony	2.3	mg/Kg - Dry	JL	1	0.5	0.63
79-34-5	Arsenic	98.6	mg/Kg - Dry	JL	1	0.5	0.63

9/9/16

Certificate of Analysis 16080701

Inorganic Analysis Data Sheet

A&B Environmental Services, dba A&B Labs
SDG No.: 16080701
Matrix: Soil
% Solids: 89
Method: EPA 6010C
Analyst: SR Gade

Client: Ecology and Environment, Inc.
Sample: 16081008
Lab Sample ID: 16080701.08
Date Collected: 08/09/2016
Date Received: 08/11/2016 10:09
Date Analyzed: 08/13/2016 01:22

CAS NO.	COMPOUND	CONCENTRATION	UNITS	Q	D.F	RL	SRL
7440-36-0	Antimony	4.4	mg/Kg - Dry	JL	1	0.5	0.56
79-34-5	Arsenic	44.5	mg/Kg - Dry	JL	1	0.5	0.56

8/19/16

Certificate of Analysis 16080701

Inorganic Analysis Data Sheet

A&B Environmental Services, dba A&B Labs
SDG No.: 16080701
Matrix: Soil
% Solids: 85.2
Method: EPA 6010C
Analyst: SR Gade

Client: Ecology and Environment, Inc.
Sample: 16081009
Lab Sample ID: 16080701.09
Date Collected: 08/09/2016
Date Received: 08/11/2016 10:09
Date Analyzed: 08/13/2016 01:28

CAS NO.	COMPOUND	CONCENTRATION	UNITS	Q	D.F	RL	SRL
7440-36-0	Antimony	2.2	mg/Kg - Dry	JC	1	0.5	0.59
79-34-5	Arsenic	30.8	mg/Kg - Dry	JC	1	0.5	0.59

MW 8/9/16

Certificate of Analysis 16080701

Inorganic Analysis Data Sheet

A&B Environmental Services, dba A&B Labs
SDG No.: 16080701
Matrix: Soil
% Solids: 80.4
Method: EPA 6010C
Analyst: SR Gade

Client: Ecology and Environment, Inc.
Sample: 16081010
Lab Sample ID: 16080701.10
Date Collected: 08/09/2016
Date Received: 08/11/2016 10:09
Date Analyzed: 08/13/2016 01:33

CAS NO.	COMPOUND	CONCENTRATION	UNITS	Q	D.F	RL	SRL
7440-36-0	Antimony	3.2	mg/Kg - Dry	JL	1	0.5	0.62
79-34-5	Arsenic	39.2	mg/Kg - Dry	JL	1	0.5	0.62

9/9/16

Certificate of Analysis 16080701

Inorganic Analysis Data Sheet

A&B Environmental Services, dba A&B Labs
SDG No.: 16080701
Matrix: Soil
% Solids: 84
Method: EPA 6010C
Analyst: SR Gade

Client: Ecology and Environment, Inc.
Sample: 16081011
Lab Sample ID: 16080701.11
Date Collected: 08/09/2016
Date Received: 08/11/2016 10:09
Date Analyzed: 08/13/2016 01:38

CAS NO.	COMPOUND	CONCENTRATION	UNITS	Q	D.F	RL	SRL
7440-36-0	Antimony	3.1	mg/Kg - Dry	JL	1	0.5	0.6
79-34-5	Arsenic	41.2	mg/Kg - Dry		1	0.5	0.6

8/9/16

Certificate of Analysis 16080701

Inorganic Analysis Data Sheet

A&B Environmental Services, dba A&B Labs
SDG No.: 16080701
Matrix: Soil
% Solids: 80.2
Method: EPA 6010C
Analyst: SR Gade

Client: Ecology and Environment, Inc.
Sample: 16081012
Lab Sample ID: 16080701.12
Date Collected: 08/09/2016
Date Received: 08/11/2016 10:09
Date Analyzed: 08/13/2016 01:44

CAS NO.	COMPOUND	CONCENTRATION	UNITS	Q	D.F	RL	SRL
7440-36-0	Antimony	1.6	mg/Kg - Dry	JL	1	0.5	0.62
79-34-5	Arsenic	32	mg/Kg - Dry		1	0.5	0.62

MW 9-19-16

Certificate of Analysis 16080701

Inorganic Analysis Data Sheet

A&B Environmental Services, dba A&B Labs
SDG No.: 16080701
Matrix: Soil
% Solids: 80.2
Method: EPA 6010C
Analyst: SR Gade

Client: Ecology and Environment, Inc.
Sample: 16081012 Duplicate
Lab Sample ID: 16080701.23
Date Collected: 08/09/2016
Date Received: 08/11/2016 10:09
Date Analyzed: 09/15/2016 21:21

CAS NO.	COMPOUND	CONCENTRATION	UNITS	Q	D.F	RL	SRL
7440-36-0	Antimony	2.37	mg/Kg - Dry	JL	1	0.5	0.62
79-34-5	Arsenic	33.8	mg/Kg - Dry		1	0.5	0.62

Certificate of Analysis 16080701

Inorganic Analysis Data Sheet

A&B Environmental Services, dba A&B Labs
SDG No.: 16080701
Matrix: Soil
% Solids: 81.7
Method: EPA 6010C
Analyst: SR Gade

Client: Ecology and Environment, Inc.
Sample: 16081013
Lab Sample ID: 16080701.13
Date Collected: 08/09/2016
Date Received: 08/11/2016 10:09
Date Analyzed: 08/13/2016 02:04
Date Analyzed: 08/15/2016 16:52

CAS NO.	COMPOUND	CONCENTRATION	UNITS	Q	D.F	RL	SRL
7440-36-0	Antimony	78.7	mg/Kg - Dry	JL	1	0.5	0.61
79-34-5	Arsenic	555	mg/Kg - Dry		20	10	12.2

Certificate of Analysis 16080701

Inorganic Analysis Data Sheet

A&B Environmental Services, dba A&B Labs
SDG No.: 16080701
Matrix: Soil
% Solids: 81.4
Method: EPA 6010C
Analyst: SR Gade

Client: Ecology and Environment, Inc.
Sample: 16081014
Lab Sample ID: 16080701.14
Date Collected: 08/09/2016
Date Received: 08/11/2016 10:09
Date Analyzed: 08/13/2016 02:09
Date Analyzed: 08/15/2016 16:56

CAS NO.	COMPOUND	CONCENTRATION	UNITS	Q	D.F	RL	SRL
7440-36-0	Antimony	75.1	mg/Kg - Dry	JL	1	0.5	0.61
79-34-5	Arsenic	475	mg/Kg - Dry		20	10	12.3

8/19/16

Certificate of Analysis 16080701

Inorganic Analysis Data Sheet

A&B Environmental Services, dba A&B Labs
SDG No.: 16080701
Matrix: Soil
% Solids: 81.9
Method: EPA 6010C
Analyst: SR Gade

Client: Ecology and Environment, Inc.
Sample: 16081015
Lab Sample ID: 16080701.15
Date Collected: 08/09/2016
Date Received: 08/11/2016 10:09
Date Analyzed: 08/13/2016 02:14

CAS NO.	COMPOUND	CONCENTRATION	UNITS	Q	D.F	RL	SRL
7440-36-0	Antimony	3.3	mg/Kg - Dry	JL	1	0.5	0.61
79-34-5	Arsenic	23.3	mg/Kg - Dry		1	0.5	0.61

8/17/16

Certificate of Analysis 16080701

Inorganic Analysis Data Sheet

A&B Environmental Services, dba A&B Labs
SDG No.: 16080701
Matrix: Soil
% Solids: 83.5
Method: EPA 6010C
Analyst: SR Gade

Client: Ecology and Environment, Inc.
Sample: 16081016
Lab Sample ID: 16080701.16
Date Collected: 08/09/2016
Date Received: 08/11/2016 10:09
Date Analyzed: 08/15/2016 18:06

CAS NO.	COMPOUND	CONCENTRATION	UNITS	Q	D.F	RL	SRL
7440-36-0	Antimony	15.2	mg/Kg - Dry	JL	10	5	6
79-34-5	Arsenic	79.2	mg/Kg - Dry		10	5	6

MW 8/19/16

Certificate of Analysis 16080701

Inorganic Analysis Data Sheet

A&B Environmental Services, dba A&B Labs
SDG No.: 16080701
Matrix: Soil
% Solids: 86.1
Method: EPA 6010C
Analyst: SR Gade

Client: Ecology and Environment, Inc.
Sample: 16081017
Lab Sample ID: 16080701.17
Date Collected: 08/09/2016
Date Received: 08/11/2016 10:09
Date Analyzed: 08/13/2016 02:24
Date Analyzed: 08/15/2016 17:02

CAS NO.	COMPOUND	CONCENTRATION	UNITS	Q	D.F	RL	SRL
7440-36-0	Antimony	36.6	mg/Kg - Dry	JL	1	0.5	0.58
79-34-5	Arsenic	268	mg/Kg - Dry		20	10	11.6

Certificate of Analysis 16080701

Inorganic Analysis Data Sheet

A&B Environmental Services, dba A&B Labs
SDG No.: 16080701
Matrix: Soil
% Solids: 81.3
Method: EPA 6010C
Analyst: SR Gade

Client: Ecology and Environment, Inc.
Sample: 16081018
Lab Sample ID: 16080701.18
Date Collected: 08/09/2016
Date Received: 08/11/2016 10:09
Date Analyzed: 08/13/2016 02:29
Date Analyzed: 08/15/2016 17:06

CAS NO.	COMPOUND	CONCENTRATION	UNITS	Q	D.F	RL	SRL
7440-36-0	Antimony	37.8	mg/Kg - Dry	JL	1	0.5	0.62
79-34-5	Arsenic	486	mg/Kg - Dry		20	10	12.3

Certificate of Analysis 16080701

Inorganic Analysis Data Sheet

A&B Environmental Services, dba A&B Labs
SDG No.: 16080701
Matrix: Soil
% Solids: 89.7
Method: EPA 6010C
Analyst: SR Gade

Client: Ecology and Environment, Inc.
Sample: 16081019
Lab Sample ID: 16080701.19
Date Collected: 08/09/2016
Date Received: 08/11/2016 10:09
Date Analyzed: 08/13/2016 02:34

CAS NO.	COMPOUND	CONCENTRATION	UNITS	Q	D.F	RL	SRL
7440-36-0	Antimony	1.3	mg/Kg - Dry	JL	1	0.5	0.56
79-34-5	Arsenic	44.1	mg/Kg - Dry		1	0.5	0.56

MW 9/9/16

Certificate of Analysis 16080701

Inorganic Analysis Data Sheet

A&B Environmental Services, dba A&B Labs
SDG No.: 16080701
Matrix: Soil
% Solids: 99.1
Method: EPA 6010C
Analyst: SR Gade

Client: Ecology and Environment, Inc.
Sample: 16081020
Lab Sample ID: 16080701.20
Date Collected: 08/09/2016
Date Received: 08/11/2016 10:09
Date Analyzed: 08/13/2016 02:39

CAS NO.	COMPOUND	CONCENTRATION	UNITS	Q	D.F	RL	SRL
7440-36-0	Antimony	2.2	mg/Kg - Dry	J	1	0.5	0.51
79-34-5	Arsenic	62.5	mg/Kg - Dry		1	0.5	0.51

9/9/16

Certificate of Analysis 16080701

Inorganic Analysis Data Sheet

A&B Environmental Services, dba A&B Labs
SDG No.: 16080701
Matrix: Soil
% Solids: 83.4
Method: EPA 6010C
Analyst: SR Gade

Client: Ecology and Environment, Inc.
Sample: 16081021
Lab Sample ID: 16080701.21
Date Collected: 08/09/2016
Date Received: 08/11/2016 10:09
Date Analyzed: 08/15/2016 16:17

CAS NO.	COMPOUND	CONCENTRATION	UNITS	Q	D.F	RL	SRL
7440-36-0	Antimony	176	mg/Kg - Dry	JL	20	10	12
79-34-5	Arsenic	670	mg/Kg - Dry	JC	20	10	12

8/19/16

Certificate of Analysis 16080701

Inorganic Analysis Data Sheet

A&B Environmental Services, dba A&B Labs
SDG No.: 16080701
Matrix: Soil
% Solids: 86.8
Method: EPA 6010C
Analyst: SR Gade

Client: Ecology and Environment, Inc.
Sample: 16081022
Lab Sample ID: 16080701.22
Date Collected: 08/09/2016
Date Received: 08/11/2016 10:09
Date Analyzed: 08/13/2016 03:20

CAS NO.	COMPOUND	CONCENTRATION	UNITS	Q	D.F	RL	SRL
7440-36-0	Antimony	6.8	mg/Kg - Dry	JL	1	0.5	0.58
79-34-5	Arsenic	60.5	mg/Kg - Dry	JL	1	0.5	0.58

MW 8-9-16

ecology and environment, inc.
Global Environmental Specialists
720 Third Avenue, Suite 1700
Seattle, Washington 98104
Tel: (206) 624-9537, Fax: (206) 621-9832

MEMORANDUM

DATE: September 30, 2016

TO: Steve Hall, START-IV Project Manager, E & E, Seattle, Washington

FROM: Mark Woodke, START-IV START-IV Chemist, E & E, Seattle, Washington MW

SUBJ: **Inorganic Data Quality Assurance Review, Opalite Mine Removal Assessment, Malheur County, Oregon**

REF: TDD: 16-03-0008 PAN: 1004530.0004.149.01

The data quality assurance review of 4 solid samples collected from the Opalite Mine Removal Assessment site in Malheur County, Oregon, has been completed. Total mercury and selective sequential extraction (SSE) analyses were performed by Eurofins Frontier Global Sciences, Inc., Bothell, Washington. All sample analyses were evaluated following EPA's Stage 2 and/or 4 Data Validation Electronic and/or Manual Process (S2B/4VE/M).

The samples were numbered:

16081015 16081018 16081019 16081020

Samples for the Selective Sequential Extraction (SSE) were prepared according to FGS-090, "Selective Sequential Extraction of Geological Samples for the Determination of Biogeochemically Relevant Inorganic Mercury Fractionation". Total mercury was analyzed in prepared SSE extracts by cold vapor atomic fluorescence spectrometry (CVAFS) according to EPA Method 1631B.

The following explains the SSE extraction steps and their anticipated biogeochemical meaning:
Elemental Mercury: Free purgeable elemental mercury
Fraction F(1): Water soluble mercury, extracted with DI water (ie: Hg_2Cl_2, $HgSO_4$)
Fraction F(2): Weak acid extractable mercury, pH2 HCl/HO Ac
Fraction F(3): Organo complexed mercury, extracted with 1N KOH
Fraction F(4): Strong complexed mercury, extracted with 12N HNO_3
Fraction F(5): Aqua Regia (cinnabar, HgSe, HgAu)

Data Qualifications:

1. Sample Holding Times: Acceptable.

The samples were received at 0.6°C. The samples were collected on August 9, 2016, were extracted by September 10, 2016 and were analyzed by September 16, 2016.

2. Initial and Continuing Calibration: Acceptable.

All applicable calibration results were within QC limits.

3. Blanks: Acceptable.

A preparation blank was analyzed for each 20 samples or per matrix per concentration level. Blanks were analyzed after each Initial or Continuing Calibration Verification. There were no detections in any blanks that potentially affected sample results.

4. Precision and Bias Determination: Not Performed.

Samples necessary to determine precision and bias were not provided to the laboratory. All results were flagged "PND" (Precision Not Determined) and "RND" (Recovery Not Determined), although the flags do not appear on the data sheets.

5. Performance Evaluation Sample Analysis: Not Provided.

Performance evaluation samples were not provided to the laboratory.

6. Matrix Spike Analysis: Acceptable.

Matrix spike analyses were performed per SDG or per matrix per concentration level, whichever was more frequent. Spike and spike duplicate recoveries were within the QC limits except when native sample concentrations were more than four times higher than the spiked amount; no actions were taken based on these outliers.

7. Duplicate Analysis: Acceptable.

A laboratory duplicate analysis was performed per SDG or per matrix per concentration level, whichever was more frequent. All duplicate results were within QC limits except some batch duplicate results; no actions were taken based on batch outliers alone.

8. Laboratory Control Sample Analysis: Acceptable.

A Laboratory Control Sample (LCS) was analyzed per SDG per matrix. All LCS results were within the established control limits.

9. Overall Assessment of Data for Use

The reviewer used professional judgment to apply a single bias qualifier when more than one bias qualifier was applicable to an individual estimated sample result. The results were dry weight corrected. Dry weight analyses were performed after holding time limits; no additional actions were taken based on these discrepancies.

The overall usefulness of the data is based on the criteria outlined in the Site-Specific Sampling Plan and/or Sampling and Quality Assurance Plan, the OSWER Directive "Quality Assurance/Quality Control Guidance for Removal Activities, Data Validation Procedures" (EPA/540/G-90/004), the analytical methods, and, when applicable, the Office of Emergency and Remedial Response Publication "National Functional Guidelines for Inorganic Superfund Data Review, August 2014". Based upon the information provided, the data are acceptable for use with the above stated data qualifications.

Data Qualifiers and Definitions

U - The analyte was analyzed for, but was not detected above the level of the reported sample quantitation limit.

J - The result is an estimated quantity. The associated numerical value is the approximate

concentration of the analyte in the sample.

JH - The result is an estimated quantity, but the result may be biased high.

JL - The result is an estimated quantity, but the result may be biased low.

JK - The result is an estimated quantity, but the result may have an unknown bias.

JQ - The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample with an unknown direction of bias and falls between the MDL and the Minimum (or Practical) Quantitation Limit (MQL, PQL).

UJ - The analyte was analyzed for, but was not detected. The reported quantitation limit is approximate and may be inaccurate or imprecise.

R - The data are unusable. The sample results are rejected due to serious deficiencies in meeting QC criteria. The analyte may or may not be present in the sample.

eurofins | Frontier Global Sciences

11720 Northcreek Pkwy N, Suite 400
Bothell, WA 98011
425.686.1996 Phone
425.686.3096 Fax

Ecology and Environment - Seattle	Project: Hg SSE In Soils And Tailings	
720 Third Avenue, Suite 1700	Project Number: Hg SSE In Soils And Tailings 2016	**Reported:**
Seattle WA, 98104	Project Manager: Steve Hall	28-Sep-16 08:29

16081015 TP06SB06

1608396-01

Analyte	Result	Detection Limit	Reporting Limit	Units	Dilution	Batch	Prepared	Sequence	Analyzed	Method	Notes
Sample Preparation: [CALC]											
Total Mercury	2620000	-	97900	ng/g dry	666667	[CALC]	09-Sep-16		15-Sep-16	EFAFS-T-AFS-SOP2822	
Sample Preparation: EFGS-019 Solids Analysis											
% Solids	78.4	-	0.1	% by Weight	1	F609317	09-Sep-16		12-Sep-16	SM 2540B	O-04, O-09
Sample Preparation: EFGS-090 Hg SSE Fraction F-1											
Mercury F-1	224000	-	18400	ng/g dry	50000	F608447	29-Aug-16	6I01008	31-Aug-16	FGS-069	
Sample Preparation: EFGS-090 Hg SSE Fraction F-2											
Mercury F-2	446000	-	18400	ng/g dry	50000	F608512	31-Aug-16	6I07007	06-Sep-16	FGS-069	
Sample Preparation: EFGS-090 Hg SSE Fraction F-3											
Mercury F-3	131000	-	7360	ng/g dry	10000	F609213	01-Sep-16	6I08010	07-Sep-16	FGS-069	
Sample Preparation: EFGS-090 Hg SSE Fraction F-4											
Mercury F-4	764000	-	36800	ng/g dry	100000	F609229	02-Sep-16	6I08008	07-Sep-16	FGS-069	
Sample Preparation: EFGS-090 Hg SSE Fraction F-5											
Mercury F-5	859000	-	15900	ng/g dry	250000	F609248	02-Sep-16	6I16004	15-Sep-16	FGS-069	
Sample Preparation: EFGS-111 HF/Aqua Regia Oven Bomb Digestion											
Mercury	2200000	-	305000	ng/g dry	500000	F609316	09-Sep-16	6I14006	13-Sep-16	EPA 1631E	
Mercury F-6	133000	-	921	ng/g dry	2500	F609315	09-Sep-16	6I15010	14-Sep-16	FGS-069	
Sample Preparation: EFGS-113 Hg Elemental Headspace											
Mercury F-0	58400	-	0.00	ng/g dry	666667	F608446	26-Aug-16	6I07008	06-Sep-16	-	

Eurofins Frontier Global Sciences, Inc.

The results in this report only apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

Amy Goodall

Amy Goodall, Project Manager

9-30-16

eurofins | Frontier Global Sciences

11720 Northcreek Pkwy N, Suite 400
Bothell, WA 98011
425.686.1996 Phone
425.686.3096 Fax

Ecology and Environment - Seattle	Project: Hg SSE In Soils And Tailings	
720 Third Avenue, Suite 1700	Project Number: Hg SSE In Soils And Tailings 2016	**Reported:**
Seattle WA, 98104	Project Manager: Steve Hall	28-Sep-16 08:29

16081015 TP06SB06

1608396-01

Analyte	Result	Detection Limit	Reporting Limit	Units	Dilution	Batch	Prepared	Sequence	Analyzed	Method	Notes

eurofins | Frontier Global Sciences

11720 Northcreek Pkwy N, Suite 400
Bothell, WA 98011
425.686.1996 Phone
425.686.3096 Fax

Ecology and Environment - Seattle	Project: Hg SSE In Soils And Tailings	
720 Third Avenue, Suite 1700	Project Number: Hg SSE In Soils And Tailings 2016	**Reported:**
Seattle WA, 98104	Project Manager: Steve Hall	28-Sep-16 08:29

16081018 TP07SB05

1608396-02

Analyte	Result	Detection Limit	Reporting Limit	Units	Dilution	Batch	Prepared	Sequence	Analyzed	Method	Notes
Sample Preparation: [CALC]											
Total Mercury	**94800**	-	7360	ng/g dry	50000	[CALC]	09-Sep-16		15-Sep-16	EFAFS-T-AFS-SOP2822	
Sample Preparation: EFGS-019 Solids Analysis											
% Solids	**80.3**	-	0.1	% by Weight	1	F609317	09-Sep-16		12-Sep-16	SM 2540B	O-04, O-09
Sample Preparation: EFGS-090 Hg SSE Fraction F-1											
Mercury F-1	**1690**	-	968	ng/g dry	2500	F608447	29-Aug-16	6I01008	31-Aug-16	FGS-069	
Sample Preparation: EFGS-090 Hg SSE Fraction F-2											
Mercury F-2	**1080**	-	968	ng/g dry	2500	F608512	31-Aug-16	6I07007	06-Sep-16	FGS-069	
Sample Preparation: EFGS-090 Hg SSE Fraction F-3											
Mercury F-3	**869**	-	387	ng/g dry	500	F609213	01-Sep-16	6I08010	07-Sep-16	FGS-069	
Sample Preparation: EFGS-090 Hg SSE Fraction F-4											
Mercury F-4	**9850**	-	968	ng/g dry	2500	F609229	02-Sep-16	6I08008	07-Sep-16	FGS-069	
Sample Preparation: EFGS-090 Hg SSE Fraction F-5											
Mercury F-5	**55700**	-	3100	ng/g dry	50000	F609248	02-Sep-16	6I16004	15-Sep-16	FGS-069	
Sample Preparation: EFGS-111 HF/Aqua Regia Oven Bomb Digestion											
Mercury	**69800**	-	1330	ng/g dry	2500	F609316	09-Sep-16	6I14006	13-Sep-16	EPA 1631E	
Mercury F-6	**25600**	-	968	ng/g dry	2500	F609315	09-Sep-16	6I15010	14-Sep-16	FGS-069	
Sample Preparation: EFGS-113 Hg Elemental Headspace											
Mercury F-0	**3.09**	-	0.00	ng/g dry	100	F608446	26-Aug-16	6I07008	06-Sep-16	-	

Eurofins Frontier Global Sciences, Inc.

The results in this report only apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

Amy Goodall

Amy Goodall, Project Manager

JW 9-30-16

eurofins | Frontier Global Sciences

11720 Northcreek Pkwy N, Suite 400
Bothell, WA 98011
425.686.1996 Phone
425.686.3096 Fax

Ecology and Environment - Seattle	Project: Hg SSE In Soils And Tailings	
720 Third Avenue, Suite 1700	Project Number: Hg SSE In Soils And Tailings 2016	Reported:
Seattle WA, 98104	Project Manager: Steve Hall	28-Sep-16 08:29

16081018 TP07SB05

1608396-02

Analyte	Result	Detection Limit	Reporting Limit	Units	Dilution	Batch	Prepared	Sequence	Analyzed	Method	Notes

eurofins | Frontier Global Sciences

11720 Northcreek Pkwy N, Suite 400
Bothell, WA 98011
425.686.1996 Phone
425.686.3096 Fax

Ecology and Environment - Seattle	Project: Hg SSE In Soils And Tailings	
720 Third Avenue, Suite 1700	Project Number: Hg SSE In Soils And Tailings 2016	**Reported:**
Seattle WA, 98104	Project Manager: Steve Hall	28-Sep-16 08:29

16081019 TP08SB05

1608396-03

Analyte	Result	Detection Limit	Reporting Limit	Units	Dilution	Batch	Prepared	Sequence	Analyzed	Method	Notes
Sample Preparation: [CALC]											
Total Mercury	152000	-	6150	ng/g dry	10000	[CALC]	10-Sep-16		16-Sep-16	EFAFS-T-AFS-SOP2822	
Sample Preparation: EFGS-019 Solids Analysis											
% Solids	91.9	-	0.1	% by Weight	1	F609317	09-Sep-16		12-Sep-16	SM 2540B	O-04, O-09
Sample Preparation: EFGS-090 Hg SSE Fraction F-1											
~~Mercury F-1~~	~~2340~~	~~-~~	~~817~~	~~ng/g dry~~	~~2500~~	~~F608447~~	~~29-Aug-16~~	~~6I01008~~	~~31-Aug-16~~	~~FGS-069~~	MW R
Mercury F-1	3540	-	1360	ng/g dry	2500	F609258	29-Aug-16	6I10003	09-Sep-16	FGS-069	
Sample Preparation: EFGS-090 Hg SSE Fraction F-2											
Mercury F-2	6240	-	817	ng/g dry	2500	F609259	08-Sep-16	6I13011	12-Sep-16	FGS-069	
Sample Preparation: EFGS-090 Hg SSE Fraction F-3											
Mercury F-3	2740	-	1360	ng/g dry	2500	F609260	06-Sep-16	6I16005	15-Sep-16	FGS-069	
Sample Preparation: EFGS-090 Hg SSE Fraction F-4											
Mercury F-4	10900	-	1360	ng/g dry	2500	F609261	10-Sep-16	6I17003	16-Sep-16	FGS-069	
Sample Preparation: EFGS-090 Hg SSE Fraction F-5											
~~Mercury F-5~~	~~17100~~	~~-~~	~~435~~	~~ng/g dry~~	~~10000~~	~~F609262~~	~~10-Sep-16~~	~~6I17001~~	~~16-Sep-16~~	~~FGS-069~~	
Sample Preparation: EFGS-111 HF/Aqua Regia Oven Bomb Digestion											
Mercury	142000	-	4800	ng/g dry	10000	F609316	09-Sep-16	6I14006	13-Sep-16	EPA 1631E	
Mercury F-6	112000	-	1360	ng/g dry	2500	F609361	13-Sep-16	6I17002	16-Sep-16	FGS-069	
Sample Preparation: EFGS-113 Hg Elemental Headspace											

Eurofins Frontier Global Sciences, Inc.

The results in this report only apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

Amy Goodall

Amy Goodall, Project Manager

9/30/16

eurofins | Frontier Global Sciences

11720 Northcreek Pkwy N, Suite 400
Bothell, WA 98011
425.686.1996 Phone
425.686.3096 Fax

Ecology and Environment - Seattle	Project: Hg SSE In Soils And Tailings	
720 Third Avenue, Suite 1700	Project Number: Hg SSE In Soils And Tailings 2016	**Reported:**
Seattle WA, 98104	Project Manager: Steve Hall	28-Sep-16 08:29

16081019 TP08SB05

1608396-03

Analyte	Result	Detection Limit	Reporting Limit	Units	Dilution	Batch	Prepared	Sequence	Analyzed	Method	Notes
Sample Preparation: EFGS-113 Hg Elemental Headspace											
Mercury F-0	6.24	-	0.00	ng/g dry	100	F608446	26-Aug-16	6I07008	06-Sep-16	-	

Eurofins Frontier Global Sciences, Inc.

Amy Goodall

Amy Goodall, Project Manager

The results in this report only apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

JMW 9-30-16

eurofins | Frontier Global Sciences

11720 Northcreek Pkwy N, Suite 400
Bothell, WA 98011
425.686.1996 Phone
425.686.3096 Fax

Ecology and Environment - Seattle	Project: Hg SSE In Soils And Tailings	
720 Third Avenue, Suite 1700	Project Number: Hg SSE In Soils And Tailings 2016	**Reported:**
Seattle WA, 98104	Project Manager: Steve Hall	28-Sep-16 08:29

16081020 OP01SS0.5

1608396-04

Analyte	Result	Detection Limit	Reporting Limit	Units	Dilution	Batch	Prepared	Sequence	Analyzed	Method	Notes
Sample Preparation: [CALC]											
Total Mercury	**1570000**	-	61400	ng/g dry	250000	[CALC]	09-Sep-16		15-Sep-16	EFAFS-T-AFS-SOP2822	
Sample Preparation: EFGS-019 Solids Analysis											
% Solids	**98.3**	-	0.1	% by Weight	1	F609317	09-Sep-16		12-Sep-16	SM 2540B	O-04, O-09
Sample Preparation: EFGS-090 Hg SSE Fraction F-1											
Mercury F-1	**158000**	-	14500	ng/g dry	50000	F608447	29-Aug-16	6I01008	31-Aug-16	FGS-069	
Sample Preparation: EFGS-090 Hg SSE Fraction F-2											
Mercury F-2	**471000**	-	14500	ng/g dry	50000	F608512	31-Aug-16	6I07007	06-Sep-16	FGS-069	
Sample Preparation: EFGS-090 Hg SSE Fraction F-3											
Mercury F-3	**168000**	-	5780	ng/g dry	10000	F609213	01-Sep-16	6I08010	07-Sep-16	FGS-069	
Sample Preparation: EFGS-090 Hg SSE Fraction F-4											
Mercury F-4	**220000**	-	14500	ng/g dry	50000	F609229	02-Sep-16	6I08008	07-Sep-16	FGS-069	
Sample Preparation: EFGS-090 Hg SSE Fraction F-5											
Mercury F-5	**483000**	-	11600	ng/g dry	250000	F609248	02-Sep-16	6I16004	15-Sep-16	FGS-069	
Sample Preparation: EFGS-111 HF/Aqua Regia Oven Bomb Digestion											
Mercury	**1960000**	-	50600	ng/g dry	100000	F609316	09-Sep-16	6I14006	13-Sep-16	EPA 1631E	
Mercury F-6	**70200**	-	723	ng/g dry	2500	F609315	09-Sep-16	6I15010	14-Sep-16	FGS-069	
Sample Preparation: EFGS-113 Hg Elemental Headspace											
Mercury F-0	**1830**	-	0.00	ng/g dry	100000	F608446	26-Aug-16	6I07008	06-Sep-16	-	

Eurofins Frontier Global Sciences, Inc.

The results in this report only apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

Amy Goodall

Amy Goodall, Project Manager

MW 9-30-16

eurofins | Frontier Global Sciences

11720 Northcreek Pkwy N, Suite 400
Bothell, WA 98011
425.686.1996 Phone
425.686.3096 Fax

Ecology and Environment - Seattle	Project: Hg SSE In Soils And Tailings	
720 Third Avenue, Suite 1700	Project Number: Hg SSE In Soils And Tailings 2016	**Reported:**
Seattle WA, 98104	Project Manager: Steve Hall	28-Sep-16 08:29

16081020 OP01SS0.5

1608396-04

Analyte	Result	Detection Limit	Reporting Limit	Units	Dilution	Batch	Prepared	Sequence	Analyzed	Method	Notes

Eurofins Frontier Global Sciences, Inc.

Amy Goodall

Amy Goodall, Project Manager

The results in this report only apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

9-30-16

This page intentionally left blank.

ATTACHMENT 3
Description of Mercury SSE Method

This page intentionally left blank.

Hg Selective Sequential Extractions (SSE):

General Method Description:

The following describes the method developed by Eurofins Frontier Global Sciences that uses a selective sequential extraction technique to accurately assess the type and concentration of mercury compounds typically found in contaminated geological sites. This method provides specific information about the expected mobility and bioaccessability of various compounds which offers a behavioural profile of the contaminant and data that can be used to assess its potential effect.

Step	Extractant	Description	Typical Compounds
F0	headspace gas	vapor equilibrium	Hg^0
F1	deionized water	water	$HgCl_2$, $HgSO_4$
F2	pH 2 HCl/HO Ac	"stomach acid"	HgO
F3	1N KOH	organo-complexed	Hg-humics, Hg_2Cl_2
F4	$12NHNO_3$	strong-complexed	mineral lattice, Hg_2, Hg^0
F5	aqua regia	cinnabar	HgS, m-HgS, HgSe, HgAu
F6	HNO_3/HCl/HF	mineral-bound	Hg in crystal lattice
FS	-	sum	total Hg

Scope:

This method is for the selective extraction of geological samples (soils, sediments, ores, mine tailings, etc.), with the goal of determining the biogeochemically relevant associations of inorganic Hg within, and leachability of inorganic Hg from, the solid phase.

When applied exactly as written, this method defines the following extraction fractions (F-0 through F-5, and F-S). The representativeness of each fraction varies from sample to sample, depending upon ancillary parameters such as TOC, soil pH, co-leached substances (i.e., Cl^-, $SO_4^=$, etc.) and actual solid phase speciation of the analyte. Additional ancillary chemistry measurements or kinetic studies may be required to fully interpret the extraction pattern for each sample.

Basic Principles:

Prior to digestion, the sample should be sieved through a 2-mm plastic mesh screen to remove large chunks, and as an aid in homogenization. Inherently fine-grained samples do not need to be sieved prior to extraction.

Fresh samples should be extracted in a form as close to their natural state as possible. Under no circumstances should samples be dried or pulverized prior to extraction, as this may lead to dramatic changes in leachability.

This method involves the sequential extraction of the ***same sample aliquot*** through a sequence of different extractants of increasing chemical strength. Recovery in a wide range of geological materials, as the sum of the selective extraction fractions was found to typically be 100 ± 15% (Table 2).

Summary Table of Eurofins Frontier Global Sciences' Mercury Selective Extraction Procedure

Fraction	Extraction Conditions	Expected Species	Expected Mobility	Expected water solubility range (20° Celsius, 1 atm)
F-0	Ambient temperature gaseous purging	Free elemental Hg	Relatively low mobility	Saturates at a concentration between 25-50 µg/L
F-1	Reagent water	Water soluble Hg salts such as $HgCl_2$, $Hg(NO_3)_2$	Highly mobile	Soluble (1 to 10 g/100 mL, $HgCl_2$ 6.57 g/100 mL)
F-2	Hydrochloric acid at a pH less than 2	Low pH soluble salts of mercury	Relatively low mobility	Slightly soluble (0.1 to 1 g/100 mL)
F-3	1 N potassium hydroxide	Organic bound mercury compounds (Hg(II) bound to sludge or humic matter)	Mobility strongly dependant on various factors	Solubility is strongly dependant on several factors including redox conditions and presence of competing complexing agents)
F-4	12 N nitric acid	All other non sulfide or silicate bound mercury compounds (can include amalgamated elemental mercury)	Low mobility	Insoluble less than 0.1 g/100 mL. Redox conditions can strongly affect the species and subsequent solubility.
F-5	Aqua regia	Sulfide bound mercury compounds only	Relatively immobile	Insoluble (HgS solubility is 2.943E-25 g/100 mL)
F-6	Combination of aqua regia and hydrofluoric acid	Silicate or aluminosilicate bound mercury compounds	Relatively immobile	Insoluble (solubility lower than HgS)

Detailed Description Of Each Step:

Volatile Elemental Mercury (Hg^o) This test is performed by placing a measured mass of the soil sample in a trace clean, teflon bomb vessel with an inlet and outlet and allowing and srubbed, Hg free nitrogen to pass over and purge the samples of free gaseous elemental Hg which in turn is captured at the outlet of the vessel using an EPA I-05/EPA 30B Hg sorbent trap. The trap is then digested using EFGS-009 and analyzed for Total Hg which represents free elemental gaseous Hg that came off the sample and reported in ng Hg (gaseous elemental Hg / gram of soil sample).

F-1 Water Soluble Mercury. Mercury extracted in this test is useful in assessing the potential leaching of soils by rain or groundwater, and is a reasonably good (±50%) predictor of the performance of the sample on an official TCLP or EP-toxicity leaching test. At high solid phase concentrations, the water soluble salts such as $HgCl_2$, $Hg(NO_3)_2$, etc., will appear largely in this fraction, but as total Hg concentrations decrease, the percentage found in this fraction decreases dramatically, due to adsorption of the free Hg on the soil particles. This fraction is extremely dependent upon the co-leached soil components such as Cl-, I-, DOC, and pH. Increases in any of these co-leached Hg complexing agents will generally greatly increase the solubility of water-soluble mercury compounds.

F-2 pH 2 Soluble Mercury. Mercury extracted in this fraction is a surrogate for what might be extracted by the human stomach upon ingestion, or of leachability under the conditions of acid mine drainage or other industrial process. In cases where the sample contains high TOC, this fraction is usually the lowest in Hg, because of readsorption of Hg(II) by coagulated humic matter at this pH. High concentrations of pH 2 leachable Hg might warrant additional testing that more accurately models the human digestive tract in terms of pH regime and contact time, or acid mine drainage conditions present at the contaminated site.

F-3 1N KOH Extractable Mercury. Under the conditions of this extraction, most of the Hg associated with humic organic matter appears to be solubilized, while none of the HgS is co-solubilized. 1N KOH soluble Hg dominates marine and freshwater sediments, as well as the soil humus layer. Not only does most of the CH_3Hg in the sample also leach out in this fraction, but also this fraction has been found to strongly correlate with *in situ* CH_3Hg concentrations, and the potential methylatability of the sample. The contribution of the CH_3Hg content to the total Hg extracted is usually small, but if high concentrations of methyl Hg (greater than 1% of total) are measured in the samples (FGS-045), a correction might be appropriate. The most appropriate way to correct this data is to also measure CH_3Hg directly on the 1N KOH extract, and subtract it from the measured total Hg value on the same extract.

F-4 12N HNO_3 Soluble Mercury. This fraction serves largely to separate out all remaining non-HgS, so that the final measured fraction may safely be taken to represent the HgS content of the sample. In cases where F-0 detected a saturation level of Hg^0, and the fractions F-1 through F-3 are small by comparison to F-4, the latter fraction may be interpreted as representing essentially the total Hg^0 content of the sample. At lower Hg concentrations in natural samples, much of the non-humic bound Hg(II) is found in this fraction, because it is strongly adsorbed to the particle surfaces, and so not leachable by the weak extractants F-1 and F-2.

F-5 Aqua Regia Soluble Mercury (Residue). If the previous steps of the extraction scheme have been carried out accurately, this fraction consists of the cinnabar and meta-cinnabar (HgS) content of the samples. Also included in this fraction, if present in the sample) would be HgSe, and amalgams of Hg with noble metals such as gold and platinum. Hg is leached from the surface of these amalgams, but the bulk concentrations require the dissolution of the noble metal particles, which is accomplished readily by aqua regia.

F-6 Mineral-Bound Mercury. For hard mineral samples, such as bauxite, the F5 (aqua regia) step is not vigorous enough to release all mercury from the crystal lattice. In samples of this type, an aggressive HF Bomb digest is necessary to recover all the mercury in the sample (SOP FGS-111).

F-S Total Mercury by the Sum of Species. The sum of all of the fractions, F-0 through F-6 is the total Hg in the sample. It is ***inadvisable*** to try to measure total Hg (FGS-137) on a separate aliquot of the sample, unless this is being done only for the purpose of assessing sample homogeneity. For real-world samples, heterogeneity is often so great that direct comparison of selective extraction on one aliquot and total Hg on a separate aliquot will produce misleading conclusions (such as that there is a "missing" Hg species, in cases where the total is much greater than the sum of species). For very fine, homogeneous samples such as CRMs, F-S should compare to the independently measured total to within ± 20%.

This leaching is optimized for and only applicable to Hg analysis. Other leaching procedures are necessary to obtain reliable and biogeochemically meaningful results for other trace metals.

This method is a protocol for the extraction only. All recovered aqueous fractions are then analyzed by an appropriate Hg quantification technique. Because of its low detection limits and high tolerance for complex matrices, EPA Method 1631 (ref 10.2), with preparation described in Frontier SOP FGS-012 (Total Hg in aqueous media) and analysis in EFGS-137 (Total Hg analysis) are recommended, as indicated in the text below.

Typical Minimum Detection Limits/Minimum Reporting Limits For Each Fraction:

Soil/Sediment

				Duplicate	Matrix Spike		Blank Spike/LCS	
Analyte	**MDL**	**MRL**	**Units**	**RPD**	**%Recovery**	**RPD**	**%Recovery**	**RPD**
Elemental Hg in soil/sediment by CV-AFS (EPA 1631 Mod)								
Mercury (0)	0.344	2.00	ng/g	24	71 - 125	25	80 - 120	24
SSE of Hg in solids (F1) (FGS-069)								
Mercury F-1	1.00	3.12	ng/g	25	75 - 125	25	0 - 125	25
SSE of Hg in solids (F2) (FGS-069)								
Mercury F-2	1.00	3.12	ng/g	25	75 - 125	25	0 - 125	25
SSE of Hg in solids (F3) (FGS-069)								
Mercury F-3	2.00	6.25	ng/g	25	75 - 125	25	0 - 125	25
SSE of Hg in solids (F4) (FGS-069)								
Mercury F-4	5.00	15.6	ng/g	25	75 - 125	25	0 - 125	25
SSE of Hg in solids (F5) (FGS-069)								
Mercury F-5	0.110	1.00	ng/g	25	75 - 125	25	0 - 125	25

This page intentionally left blank.